



US009408599B2

(12) **United States Patent**
Kaiser et al.

(10) **Patent No.:** **US 9,408,599 B2**
(45) **Date of Patent:** ***Aug. 9, 2016**

(54) **METHOD AND APPARATUS FOR COUPLING
SOFT TISSUE TO A BONE**

408/9045; Y10T 409/300056; Y10T
409/300112

See application file for complete search history.

(75) Inventors: **Ryan A. Kaiser**, Leesburg, IN (US);
Kevin T. Stone, Winona Lake, IN (US)

(56)

References Cited

U.S. PATENT DOCUMENTS

394,739 A 12/1888 Toulmin
3,081,781 A 3/1963 Sterner

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0019062 A1 11/1980
EP 1864617 B1 10/2009

(Continued)

OTHER PUBLICATIONS

International Search Report and Written Opinion mailed May 23,
2012 for PCT/US2012/030294 claiming benefit of U.S. Appl. No.
13/071,563, filed Mar. 25, 2011.

(Continued)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 1122 days.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **13/311,936**

(22) Filed: **Dec. 6, 2011**

(65) **Prior Publication Data**

US 2012/0095470 A1 Apr. 19, 2012

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/474,802,
filed on May 29, 2009, now Pat. No. 8,088,130, which
is a continuation-in-part of application No.
11/541,506, filed on Sep. 29, 2006, now Pat. No.

(Continued)

(51) **Int. Cl.**

A61B 17/10 (2006.01)

A61B 17/04 (2006.01)

A61B 17/16 (2006.01)

A61B 17/00 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC **A61B 17/0401** (2013.01); **A61B 17/06166**
(2013.01); **A61B 17/1617** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC A61B 17/0401; A61B 17/1617; A61B
17/1675; A61B 17/06166; A61F 2/0805;
A61F 2/0811; Y10T 408/9048; Y10T

Primary Examiner — Gregory Anderson

Assistant Examiner — Son Dang

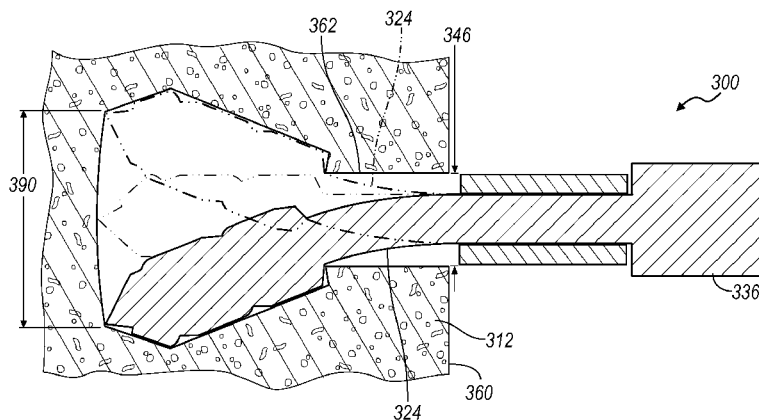
(74) *Attorney, Agent, or Firm* — Schwegman Lundberg &
Woessner, P.A.

(57)

ABSTRACT

A method and apparatus for coupling a soft tissue implant into
a locking cavity formed within a bone is disclosed. The
method includes bringing a bone cutting tool extending along
a longitudinal axis into engagement with an outer surface of
the bone. The bone cutting tool is rotated about the longitu-
dinal axis while driving it from the outer surface of the bone
to a predetermined depth in the bone to form a bore. The bone
cutting tool is then continuously rotated at the predetermined
depth to establish an enlarged bone pocket at a distal end of
the bore. The bone pocket defines a shoulder extending
around a circumference between the bone pocket and bore.
The bone cutting tool is removed from the bone pocket and
bore. The fixation device is then inserted into the bone pocket
through the bore, where it is seated against the bone pocket
shoulder.

20 Claims, 53 Drawing Sheets



Related U.S. Application Data

7,601,165, and a continuation-in-part of application No. 11/541,505, filed on Sep. 29, 2006, now Pat. No. 7,658,751, and a continuation-in-part of application No. 12/014,399, filed on Jan. 15, 2008, now Pat. No. 7,909,851, and a continuation-in-part of application No. 12/014,340, filed on Jan. 15, 2008, now Pat. No. 7,905,904, and a continuation-in-part of application No. 11/935,681, filed on Nov. 6, 2007, now Pat. No. 7,905,903, and a continuation-in-part of application No. 11/869,440, filed on Oct. 9, 2007, now Pat. No. 7,857,830, and a continuation-in-part of application No. 11/784,821, filed on Apr. 10, 2007, and a continuation-in-part of application No. 11/347,661, filed on Feb. 3, 2006, now Pat. No. 7,749,250, and a continuation-in-part of application No. 11/347,662, filed on Feb. 3, 2006, now abandoned, and application No. 13/311,936, Dec. 6, 2011, which is a continuation-in-part of application No. 12/196,405, filed on Aug. 22, 2008, now Pat. No. 8,128,658, and a continuation-in-part of application No. 12/196,407, filed on Aug. 22, 2008, now Pat. No. 8,137,382, and a continuation-in-part of application No. 12/196,410, filed on Aug. 22, 2008, now Pat. No. 8,118,836, and a continuation-in-part of application No. 13/071,563, filed on Mar. 25, 2011.

(51) **Int. Cl.**

A61B 17/06 (2006.01)

A61F 2/08 (2006.01)

(52) **U.S. Cl.**

CPC *A61B17/1675* (2013.01); *A61F 2/0805* (2013.01); *A61F 2/0811* (2013.01); *A61B 17/0469* (2013.01); *A61B 17/0485* (2013.01); *A61B 17/0487* (2013.01); *A61B 17/1631* (2013.01); *A61B 17/1633* (2013.01); *A61B 17/1655* (2013.01); *A61B 2017/00004* (2013.01); *A61B 2017/00336* (2013.01); *A61B 2017/00858* (2013.01); *A61B 2017/044* (2013.01); *A61B 2017/0406* (2013.01); *A61B 2017/0409* (2013.01); *A61B 2017/0414* (2013.01); *A61B 2017/0417* (2013.01); *A61B 2017/0432* (2013.01); *A61B 2017/0477* (2013.01); *A61B 2017/0496* (2013.01); *A61B 2017/06185* (2013.01); *A61F 2/08* (2013.01); *A61F 2002/0829* (2013.01); *A61F 2002/0835* (2013.01); *A61F 2002/0852* (2013.01); *A61F 2002/0864* (2013.01); *A61F 2002/0882* (2013.01); *A61F 2002/0888* (2013.01)

(56)

References Cited

U.S. PATENT DOCUMENTS

3,650,274 A 3/1972 Edwards et al.
4,146,022 A 3/1979 Johnson et al.
4,158,250 A 6/1979 Ringwald
4,275,490 A 6/1981 Bivins
4,388,921 A 6/1983 Sutter et al.
4,489,464 A 12/1984 Massari et al.
4,736,746 A 4/1988 Anderson
4,738,255 A 4/1988 Goble et al.
4,751,922 A 6/1988 DiPietropolo
4,790,850 A 12/1988 Dunn et al.
4,858,603 A 8/1989 Clemow et al.
4,884,572 A 12/1989 Bays et al.
4,889,110 A 12/1989 Galline et al.
4,974,488 A 12/1990 Spralja

5,020,713 A 6/1991 Kunreuther
5,064,431 A 11/1991 Gilbertson et al.
5,171,274 A 12/1992 Fluckiger et al.
5,190,545 A 3/1993 Corsi et al.
5,199,135 A 4/1993 Gold
5,415,658 A 5/1995 Kilpela et al.
5,417,690 A 5/1995 Sennett et al.
5,423,824 A * 6/1995 Akerfeldt et al. 606/80
5,441,508 A 8/1995 Gazielly et al.
5,456,721 A 10/1995 Legrand
5,464,426 A 11/1995 Bonutti
5,495,974 A 3/1996 Deschenes et al.
5,531,759 A 7/1996 Kensey et al.
5,549,630 A 8/1996 Bonutti
5,573,547 A 11/1996 LeVeen et al.
5,607,430 A 3/1997 Bailey
5,649,960 A 7/1997 Pavletic
5,715,578 A 2/1998 Knudson
5,725,557 A 3/1998 Gattorna et al.
5,741,259 A 4/1998 Chan
5,797,913 A 8/1998 Dambreville et al.
5,817,095 A 10/1998 Smith
5,824,066 A 10/1998 Gross
5,836,955 A 11/1998 Buelna et al.
5,849,012 A 12/1998 Abboudi
5,885,294 A 3/1999 Pedlick et al.
5,935,134 A 8/1999 Pedlick et al.
5,980,548 A 11/1999 Evans et al.
5,989,252 A 11/1999 Fumex
6,036,695 A 3/2000 Smith
6,041,485 A * 3/2000 Pedlick et al. 29/450
6,110,207 A 8/2000 Eichhorn et al.
6,136,010 A 10/2000 Modesitt et al.
6,334,064 B1 12/2001 Fiddian-Green
6,368,326 B1 4/2002 Dakin et al.
6,425,924 B1 7/2002 Rousseau
6,485,504 B1 11/2002 Johnson et al.
RE37,963 E 1/2003 Thal
6,511,498 B1 1/2003 Fumex
6,514,274 B1 2/2003 Boucher et al.
6,543,094 B2 4/2003 D'addario
6,554,852 B1 4/2003 Oberlander
6,592,609 B1 7/2003 Bonutti
6,626,930 B1 9/2003 Allen et al.
6,638,286 B1 10/2003 Burbank et al.
6,645,211 B2 11/2003 Magana
6,648,921 B2 11/2003 Anderson et al.
6,669,707 B1 12/2003 Swanstrom et al.
6,682,533 B1 1/2004 Dinsdale et al.
6,712,859 B2 3/2004 Rousseau
6,730,124 B2 5/2004 Steiner
6,755,868 B2 6/2004 Rousseau
6,790,210 B1 9/2004 Cragg et al.
6,793,595 B1 9/2004 Monnet
7,083,638 B2 8/2006 Foerster
7,207,993 B1 4/2007 Baldwin et al.
7,303,577 B1 12/2007 Dean
7,481,814 B1 1/2009 Metzger
7,485,149 B1 2/2009 White
7,572,275 B2 8/2009 Fallin et al.
7,601,165 B2 10/2009 Stone
7,658,751 B2 2/2010 Stone et al.
7,703,372 B1 4/2010 Shakespeare
7,749,250 B2 7/2010 Stone et al.
7,762,942 B2 7/2010 Neisz et al.
7,790,945 B1 9/2010 Watson, Jr.
7,828,820 B2 11/2010 Stone et al.
7,856,698 B2 12/2010 Hays
7,857,830 B2 12/2010 Stone et al.
7,867,252 B2 * 1/2011 Criscuolo et al. 606/232
7,905,903 B2 3/2011 Stone et al.
7,905,904 B2 3/2011 Stone et al.
7,909,851 B2 3/2011 Stone et al.
7,914,539 B2 3/2011 Stone et al.
7,959,650 B2 6/2011 Kaiser et al.
8,034,090 B2 10/2011 Stone et al.
8,088,130 B2 1/2012 Kaiser et al.
8,118,835 B2 2/2012 Weisel et al.
8,118,836 B2 2/2012 Denham et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

8,118,868 B2	2/2012	May et al.	2005/0090827 A1	4/2005	Gedebou
8,128,658 B2	3/2012	Kaiser et al.	2005/0137624 A1	6/2005	Fallman
8,137,382 B2	3/2012	Denham et al.	2005/0149118 A1	7/2005	Koyfman et al.
8,177,810 B2	5/2012	Ferree	2005/0187577 A1	8/2005	Selvitelli et al.
8,231,654 B2	7/2012	Kaiser et al.	2005/0192632 A1	9/2005	Geissler et al.
8,251,998 B2	8/2012	Hoepfner et al.	2005/0251153 A1	11/2005	Sakamoto et al.
8,273,106 B2	9/2012	Stone et al.	2005/0251159 A1	11/2005	Ewers et al.
8,292,921 B2	10/2012	Stone et al.	2005/0251209 A1	11/2005	Saadat et al.
8,298,262 B2	10/2012	Stone et al.	2006/0004364 A1	1/2006	Green et al.
8,303,604 B2	11/2012	Stone et al.	2006/0030884 A1	2/2006	Yeung et al.
8,317,825 B2	11/2012	Stone	2006/0149266 A1	7/2006	Cordasco
8,337,525 B2	12/2012	Stone et al.	2006/0189993 A1	8/2006	Stone
8,343,155 B2	1/2013	Fisher et al.	2006/0190042 A1	8/2006	Stone et al.
8,343,227 B2	1/2013	Metzger et al.	2006/0195106 A1	8/2006	Jones et al.
8,361,113 B2	1/2013	Stone et al.	2006/0212055 A1	9/2006	Karabey et al.
8,409,253 B2	4/2013	Stone et al.	2006/0229623 A1	10/2006	Bonutti et al.
8,486,114 B2	7/2013	Gillard et al.	2006/0229676 A1	10/2006	Doll et al.
8,500,818 B2	8/2013	Metzger et al.	2006/0253130 A1	11/2006	Wolniewicz, II
8,551,140 B2	10/2013	Denham et al.	2006/0259076 A1	11/2006	Burkhart
8,562,645 B2	10/2013	Stone et al.	2006/0264944 A1	11/2006	Cole
8,562,647 B2	10/2013	Kaiser et al.	2006/0276896 A1	12/2006	Fallin et al.
8,574,235 B2	11/2013	Stone	2006/0282085 A1	12/2006	Stone
8,579,944 B2	11/2013	Holloway et al.	2007/0005068 A1	1/2007	Sklar
8,597,327 B2	12/2013	Stone et al.	2007/0010857 A1	1/2007	Sugimoto et al.
8,608,777 B2	12/2013	Kaiser et al.	2007/0027476 A1	2/2007	Harris et al.
8,632,569 B2	1/2014	Stone et al.	2007/0032800 A1	2/2007	Ortiz et al.
8,652,171 B2	2/2014	Stone et al.	2007/0032823 A1	2/2007	Tegg
8,652,172 B2	2/2014	Denham et al.	2007/0043371 A1	2/2007	Teague
8,672,968 B2	3/2014	Stone et al.	2007/0071568 A1	3/2007	Dorstewitz
8,672,969 B2	3/2014	Stone et al.	2007/0073319 A1	3/2007	Mikkaichi et al.
8,721,684 B2	5/2014	Denham et al.	2007/0073322 A1	3/2007	Mikkaichi et al.
8,771,316 B2	7/2014	Denham et al.	2007/0088362 A1	4/2007	Bonutti et al.
8,777,956 B2	7/2014	Hoepfner et al.	2007/0112384 A1	5/2007	Conlon et al.
8,801,783 B2	8/2014	Stone et al.	2007/0123984 A1	5/2007	Hodorek
8,840,645 B2	9/2014	Denham et al.	2007/0156174 A1	7/2007	Kaiser et al.
8,900,314 B2	12/2014	Metzger et al.	2007/0167950 A1	7/2007	Tauro et al.
8,926,613 B2	1/2015	Kaiser et al.	2007/0219558 A1	9/2007	Deutsch
8,932,331 B2	1/2015	Kaiser et al.	2007/0225715 A1	9/2007	Deffenbaugh et al.
8,936,621 B2	1/2015	Denham et al.	2007/0250059 A1	10/2007	Weissaupt et al.
8,968,364 B2	3/2015	Berelsman	2007/0265704 A1	11/2007	Mayer et al.
8,998,949 B2	4/2015	Stone et al.	2007/0288023 A1	12/2007	Pellegrino et al.
9,005,287 B2	4/2015	Stone	2008/0027440 A1	1/2008	Marissen et al.
9,017,381 B2	4/2015	Kaiser et al.	2008/0082128 A1	4/2008	Stone
9,023,058 B2	5/2015	Jaramillo et al.	2008/0177302 A1	7/2008	Shurnas
9,078,644 B2	7/2015	Stone	2008/0208252 A1	8/2008	Holmes
9,149,267 B2	10/2015	Norton et al.	2008/0255613 A1	10/2008	Kaiser et al.
9,173,651 B2	11/2015	Stone et al.	2008/0319478 A1	12/2008	Foerster et al.
9,198,673 B2	12/2015	Stone	2009/0018655 A1	1/2009	Brunelle et al.
9,216,078 B2	12/2015	Conner et al.	2009/0062847 A1	3/2009	Ken
2001/0041916 A1	11/2001	Bonutti	2009/0082790 A1	3/2009	Shad et al.
2001/0051815 A1	12/2001	Esplin	2009/0105717 A1	4/2009	Bluechel
2002/0019649 A1	2/2002	Sikora et al.	2009/0138002 A1	5/2009	Fenton
2002/0068254 A1	6/2002	Campbell	2009/0240335 A1	9/2009	Arcenio et al.
2002/0156475 A1	10/2002	Lerch et al.	2009/0265015 A1	10/2009	May et al.
2002/0177853 A1	11/2002	Chervitz et al.	2009/0287215 A1	11/2009	Fisher et al.
2003/0105489 A1	6/2003	Eichhorn et al.	2009/0312793 A1	12/2009	Huxel et al.
2003/0139752 A1	7/2003	Pasricha et al.	2010/0016899 A1	1/2010	Gelfand
2003/0139775 A1	7/2003	Grafton	2010/0063541 A1	3/2010	Brunelle et al.
2003/0208209 A1	11/2003	Gambale et al.	2010/0094355 A1	4/2010	Trenhaile
2003/0208210 A1	11/2003	Dreyfuss et al.	2010/0106254 A1	4/2010	Delsignore
2003/0212456 A1	11/2003	Lipchitz et al.	2010/0121348 A1	5/2010	Van Der Burg et al.
2003/0220646 A1*	11/2003	Thelen	2010/0152752 A1	6/2010	Denove et al.
			2010/0204700 A1	8/2010	Falahee
			2010/0211071 A1	8/2010	Lettmann et al.
			2010/0211075 A1	8/2010	Stone
			2011/0087225 A1	4/2011	Fritzinger
			2011/0098727 A1	4/2011	Kaiser et al.
			2011/0106153 A1	5/2011	Stone et al.
			2011/0112538 A1	5/2011	Dell'oca
			2012/0041486 A1	2/2012	Stone et al.
			2012/0053630 A1	3/2012	Denham et al.
			2012/0059417 A1	3/2012	Norton et al.
			2012/0059418 A1	3/2012	Denham et al.
			2012/0059468 A1	3/2012	Mattern et al.
			2012/0095470 A1	4/2012	Kaiser et al.
			2012/0245585 A1	9/2012	Kaiser et al.
			2012/0265219 A1	10/2012	Rushdy et al.
			2012/0290003 A1	11/2012	Dreyfuss
			2013/0023930 A1	1/2013	Stone et al.
2003/0229361 A1	12/2003	Jackson			
2003/0236555 A1	12/2003	Thornes			
2004/0073176 A1	4/2004	Utterberg			
2004/0127907 A1	7/2004	Dakin et al.			
2004/0138683 A1	7/2004	Shelton et al.			
2004/0204722 A1	10/2004	Sikora et al.			
2004/0225305 A1	11/2004	Ewers et al.			
2004/0267317 A1	12/2004	Higgins et al.			
2005/0004670 A1	1/2005	Gebhardt et al.			
2005/0033363 A1	2/2005	Bojarski et al.			
2005/0049598 A1	3/2005	West, Jr. et al.			
2005/0076478 A1	4/2005	Miyazaki et al.			

A61B 17/1642
606/79

(56)

References Cited**U.S. PATENT DOCUMENTS**

2013/0035698	A1	2/2013	Stone et al.
2013/0046341	A1	2/2013	Stone et al.
2013/0116730	A1	5/2013	Denham et al.
2013/0138123	A1	5/2013	Stone et al.
2013/0144337	A1	6/2013	Stone et al.
2013/0144338	A1	6/2013	Stone et al.
2013/0158601	A1	6/2013	Stone et al.
2013/0190818	A1	7/2013	Norton
2013/0190819	A1	7/2013	Norton
2013/0204276	A1	8/2013	Stone et al.
2013/0211452	A1	8/2013	Stone et al.
2013/0317621	A1	11/2013	Metzger et al.
2014/0046367	A1	2/2014	Stone et al.
2014/0046368	A1	2/2014	Kaiser et al.
2014/0067081	A1	3/2014	Stone
2014/0088655	A1	3/2014	Stone et al.
2014/0094913	A1	4/2014	Berelsman et al.
2014/0135835	A1	5/2014	Stone et al.
2014/0163613	A1	6/2014	Stone et al.
2014/0163614	A1	6/2014	Denham et al.
2014/0194927	A1	7/2014	Kaiser et al.
2014/0200583	A1	7/2014	Stone et al.
2014/0276992	A1	9/2014	Stone et al.
2014/0324101	A1	10/2014	Denham et al.
2014/0330311	A1	11/2014	Denham et al.
2014/0350674	A1	11/2014	Stone et al.
2015/0012094	A1	1/2015	Denham et al.
2015/0057757	A1	2/2015	Metzger et al.
2015/0119890	A1	4/2015	Kaiser et al.
2015/0127051	A1	5/2015	Kaiser et al.
2015/0134000	A1	5/2015	Denham et al.
2015/0173887	A1	6/2015	Berelsman et al.
2015/0257750	A1	9/2015	Kaiser et al.
2016/0000483	A1	1/2016	Stone

FOREIGN PATENT DOCUMENTS

WO	WO-2007119057	A1	10/2007
WO	WO-2010138832	A1	12/2010
WO	WO-2012134999	A1	10/2012

OTHER PUBLICATIONS

International Preliminary Report on Patentability mailed Oct. 10, 2013 for PCT/US2012/030294 which claims benefit of U.S. Appl. No. 13/071,563, filed Mar. 25, 2011.

"U.S. Appl. No. 11/504,882, Supplemental Notice of Allowability mailed Mar. 12, 2015", 5 pgs.

"U.S. Appl. No. 12/719,337, Notice of Allowance mailed Mar. 11, 2015", 10 pgs.

"U.S. Appl. No. 13/098,927, Response filed Jul. 22, 2015 to Final Office Action mailed May 22, 2013", 17 pgs.

"U.S. Appl. No. 13/281,009, Non Final Office Action mailed Jun. 2, 2015", 9 pgs.

"U.S. Appl. No. 13/281,009, Notice of Allowance mailed Oct. 29, 2015", 8 pgs.

"U.S. Appl. No. 13/281,009, Response filed Sep. 2, 2015 to Non Final Office Action mailed Jun. 2, 2015", 13 pgs.

"U.S. Appl. No. 13/281,009, Restriction Requirement mailed Feb. 11, 2015", 6 pgs.

"U.S. Appl. No. 13/288,459, Examiner Interview Summary mailed Feb. 6, 2015", 3 pgs.

"U.S. Appl. No. 13/288,459, Non Final Office Action mailed Jun. 24, 2015", 10 pgs.

"U.S. Appl. No. 13/288,459, Notice of Allowance mailed Jan. 11, 2016", 13 pgs.

"U.S. Appl. No. 13/288,459, Response filed Mar. 3, 2015 to Non Final Office Action mailed Nov. 4, 2014", 16 pgs.

"U.S. Appl. No. 13/288,459, Response filed Oct. 23, 2015 to Non Final Office Action mailed Jun. 24, 2015", 14 pgs.

"U.S. Appl. No. 13/293,825, Notice of Allowability mailed Jun. 22, 2015", 7 pgs.

"U.S. Appl. No. 13/293,825, Notice of Allowance mailed May 19, 2015", 9 pgs.

"U.S. Appl. No. 13/293,825, Response filed Apr. 15, 2015 to Restriction Requirement mailed Feb. 12, 2015", 17 pgs.

"U.S. Appl. No. 13/293,825, Restriction Requirement mailed Feb. 12, 2015", 9 pgs.

"U.S. Appl. No. 13/295,126, Non Final Office Action mailed May 19, 2015", 9 pgs.

"U.S. Appl. No. 13/295,126, Notice of Allowance mailed Oct. 22, 2015", 9 pgs.

"U.S. Appl. No. 13/295,126, Response filed Apr. 13, 2015 to Restriction Requirement mailed Feb. 12, 2015", 1 pgs.

"U.S. Appl. No. 13/295,126, Response filed Aug. 17, 2015 to Non Final Office Action mailed May 19, 2015", 21 pgs.

"U.S. Appl. No. 13/295,126, Restriction Requirement mailed Feb. 12, 2015", 9 pgs.

"U.S. Appl. No. 13/350,985, Final Office Action mailed Apr. 16, 2015", 8 pgs.

"U.S. Appl. No. 13/350,985, Notice of Allowance mailed Jul. 27, 2015", 5 pgs.

"U.S. Appl. No. 13/350,985, Response filed Mar. 13, 2015 to Non Final Office Action mailed Dec. 15, 2014", 10 pgs.

"U.S. Appl. No. 13/350,985, Response filed Jul. 9, 2015 to Final Office Action mailed Apr. 16, 2015", 8 pgs.

"U.S. Appl. No. 13/625,413, Final Office Action mailed Oct. 30, 2015", 8 pgs.

"U.S. Appl. No. 13/625,413, Non Final Office Action mailed Jun. 8, 2015", 11 pgs.

"U.S. Appl. No. 13/625,413, Notice of Allowance mailed Dec. 11, 2015", 9 pgs.

"U.S. Appl. No. 13/625,413, Response filed May 11, 2015 to Restriction Requirement mailed Mar. 10, 2015", 1 pg.

"U.S. Appl. No. 13/625,413, Response filed Sep. 8, 2015 to Non Final Office Action mailed Jun. 8, 2015", 16 pgs.

"U.S. Appl. No. 13/625,413, Response filed Dec. 1, 2015 to Final Office Action mailed Oct. 30, 2015", 9 pgs.

"U.S. Appl. No. 13/625,413, Restriction Requirement mailed Mar. 10, 2015", 7 pgs.

"U.S. Appl. No. 13/645,964, Final Office Action mailed Oct. 6, 2015", 17 pgs.

"U.S. Appl. No. 13/645,964, Non Final Office Action mailed Mar. 17, 2015", 15 pgs.

"U.S. Appl. No. 13/645,964, Response filed Jul. 17, 2015 to Non Final Office Action mailed Mar. 17, 2015", 17 pgs.

"U.S. Appl. No. 13/645,964, Response filed Dec. 4, 2015 to Final Office Action mailed Oct. 6, 2015", 14 pgs.

"U.S. Appl. No. 13/656,821, Notice of Allowance mailed Jun. 18, 2015", 11 pgs.

"U.S. Appl. No. 13/656,821, Response filed May 11, 2015 to Restriction Requirement mailed Mar. 10, 2015", 1 pg.

"U.S. Appl. No. 13/656,821, Restriction Requirement mailed Mar. 10, 2015", 6 pgs.

"U.S. Appl. No. 13/720,648, Final Office Action mailed Nov. 16, 2015", 7 pgs.

"U.S. Appl. No. 13/720,648, Non Final Office Action mailed Jun. 10, 2015", 11 pgs.

"U.S. Appl. No. 13/720,648, Response filed Jan. 13, 2016 to Final Office Action mailed Nov. 16, 2015", 9 pgs.

"U.S. Appl. No. 13/720,648, Response filed May 11, 2015 to Restriction Requirement mailed Mar. 10, 2015", 8 pgs.

"U.S. Appl. No. 13/720,648, Response filed Oct. 9, 2015 to Non Final Office Action mailed Jun. 10, 2015", 12 pgs.

"U.S. Appl. No. 13/720,648, Restriction Requirement mailed Mar. 10, 2015", 8 pgs.

"U.S. Appl. No. 13/751,846, Final Office Action mailed Nov. 17, 2015", 9 pgs.

"U.S. Appl. No. 13/751,846, Non Final Office Action mailed Jun. 15, 2015", 10 pgs.

"U.S. Appl. No. 13/751,846, Response filed May 11, 2015 to Restriction Requirement mailed Mar. 10, 2015", 15 pgs.

"U.S. Appl. No. 13/751,846, Response filed Oct. 9, 2015 to Non Final Office Action mailed Jun. 15, 2015", 20 pgs.

(56)

References Cited**OTHER PUBLICATIONS**

"U.S. Appl. No. 13/751,846, Restriction Requirement mailed Mar. 10, 2015", 7 pgs.

"U.S. Appl. No. 13/757,003, Non Final Office Action mailed Jun. 25, 2015", 8 pgs.

"U.S. Appl. No. 13/757,003, Response filed May 12, 2015 to Restriction Requirement mailed Mar. 12, 2015", 9 pgs.

"U.S. Appl. No. 13/757,003, Response filed Oct. 26, 2015 to Non Final Office Action mailed Jul. 25, 2015", 8 pgs.

"U.S. Appl. No. 13/757,003, Restriction Requirement mailed Mar. 12, 2015", 6 pgs.

"U.S. Appl. No. 13/757,019, Non Final Office Action mailed Jun. 25, 2015", 11 pgs.

"U.S. Appl. No. 13/757,019, Notice of Allowance mailed Dec. 10, 2015", 10 pgs.

"U.S. Appl. No. 13/757,019, Response filed May 11, 2015 to Restriction Requirement mailed Mar. 11, 2015", 9 pgs.

"U.S. Appl. No. 13/757,019, Response filed Oct. 26, 2015 to Non Final Office Action mailed Jun. 25, 2015", 9 pgs.

"U.S. Appl. No. 13/757,019, Restriction Requirement mailed Mar. 11, 2015", 10 pgs.

"U.S. Appl. No. 13/767,401, Non Final Office Action mailed Aug. 26, 2015", 9 pgs.

"U.S. Appl. No. 13/767,401, Notice of Allowance mailed Dec. 30, 2015", 9 pgs.

"U.S. Appl. No. 13/767,401, Response filed May 18, 2015 to Restriction Requirement mailed Mar. 17, 2015", 15 pgs.

"U.S. Appl. No. 13/767,401, Response filed Nov. 6, 2015 to Non Final Office Action mailed Aug. 26, 2015", 12 pgs.

"U.S. Appl. No. 13/767,401, Restriction Requirement mailed Mar. 17, 2015", 8 pgs.

"U.S. Appl. No. 13/790,982, Examiner Interview Summary mailed Jun. 9, 2015", 3 pgs.

"U.S. Appl. No. 13/790,982, Non Final Office Action mailed Sep. 16, 2015", 11 pgs.

"U.S. Appl. No. 13/790,982, Response filed Jun. 2, 2015 to Restriction Requirement mailed Apr. 2, 2015", 11 pgs.

"U.S. Appl. No. 13/790,982, Response filed Dec. 16, 2015 to Non Final Office Action mailed Sep. 16, 2015", 10 pgs.

"U.S. Appl. No. 13/790,982, Restriction Requirement mailed Apr. 2, 2015", 10 pgs.

"U.S. Appl. No. 13/790,997, Examiner interview Summary mailed Jun. 8, 2015", 3 pgs.

"U.S. Appl. No. 13/790,997, Non Final Office Action mailed Sep. 21, 2015", 8 pgs.

"U.S. Appl. No. 13/790,997, Response filed Jun. 2, 2015 to Restriction Requirement mailed Apr. 2, 2015", 12 pgs.

"U.S. Appl. No. 13/790,997, Response filed Dec. 18, 2015 to Non Final Office Action mailed Sep. 21, 2015", 9 pgs.

"U.S. Appl. No. 13/790,997, Restriction Requirement mailed Apr. 2, 2015", 8 pgs.

"U.S. Appl. No. 13/833,567, Non Final Office Action mailed Oct. 23, 2015", 10 pgs.

"U.S. Appl. No. 13/833,567, Response filed Jun. 25, 2015 to Restriction Requirement mailed Apr. 3, 2015", 10 pgs.

"U.S. Appl. No. 13/833,567, Restriction Requirement mailed Apr. 3, 2015", 6 pgs.

"U.S. Appl. No. 13/838,755, Non Final Office Action mailed Sep. 17, 2015", 11 pgs.

"U.S. Appl. No. 13/838,755, Response filed Jun. 8, 2015 to Restriction Requirement mailed Apr. 6, 2015", 1 pg.

"U.S. Appl. No. 13/838,755, Response filed Dec. 1, 2015 to Non Final Office Action mailed Sep. 17, 2015", 13 pgs.

"U.S. Appl. No. 13/838,755, Restriction Requirement mailed Apr. 6, 2015", 6 pgs.

"U.S. Appl. No. 13/889,851, Non Final Office Action mailed Apr. 6, 2015", 10 pgs.

"U.S. Appl. No. 13/889,851, Notice of Allowance mailed Aug. 12, 2015", 8 pgs.

"U.S. Appl. No. 13/889,851, Response filed Feb. 26, 2015 to Restriction Requirement mailed Jan. 21, 2015", 12 pgs.

"U.S. Appl. No. 13/889,851, Response filed Jul. 6, 2015 to Non Final Office Action mailed Apr. 6, 2015", 14 pgs.

"U.S. Appl. No. 13/889,851, Restriction Requirement mailed Jan. 21, 2015", 6 pgs.

"U.S. Appl. No. 13/889,851, Supplemental Amendment and Response filed Jul. 6, 2015 to Non Final Office Action mailed Apr. 6, 2015", 8 pgs.

"U.S. Appl. No. 13/959,145, Final Office Action mailed Feb. 5, 2015", 22 pgs.

"U.S. Appl. No. 13/959,145, Non Final Office Action mailed Jul. 31, 2015", 21 pgs.

"U.S. Appl. No. 13/959,145, Response filed Jul. 6, 2015 to Final Office Action mailed Feb. 5, 2015", 18 pgs.

"U.S. Appl. No. 13/959,145, Response filed Oct. 30, 2015 to Non Final Office Action mailed Jul. 31, 2015", 14 pgs.

"U.S. Appl. No. 14/071,295, Supplemental Notice of Allowability mailed Jan. 26, 2015", 2 pgs.

"U.S. Appl. No. 14/324,688, Non Final Office Action mailed Jan. 8, 2016", 18 pgs.

"U.S. Appl. No. 14/456,286, Non Final Office Action mailed Dec. 30, 2015", 16 pgs.

"U.S. Appl. No. 14/456,286, Response filed Dec. 11, 2015 to Restriction Requirement mailed Oct. 29, 2015", 6 pgs.

"U.S. Appl. No. 14/456,286, Restriction Requirement mailed Oct. 29, 2015", 9 pgs.

"U.S. Appl. No. 14/589,101, Final Office Action mailed Oct. 2, 2015", 10 pgs.

"U.S. Appl. No. 14/589,101, Non Final Office Action mailed Feb. 12, 2015", 10 pgs.

"U.S. Appl. No. 14/589,101, Response filed Jun. 12, 2015 to Non Final Office Action mailed Feb. 12, 2015", 11 pgs.

"U.S. Appl. No. 14/589,101, Response filed Dec. 29, 2015 to Final Office Action mailed Oct. 2, 2015", 15 pgs.

"U.S. Appl. No. 14/794,309, Preliminary Amendment filed Sep. 22, 2015", 6 pgs.

"U.S. Appl. No. 14/876,167, Preliminary Amendment filed Oct. 27, 2015", 8 pgs.

"U.S. Appl. No. 14/936,831, Preliminary Amendment filed Nov. 11, 2015", 6 pgs.

"U.S. Appl. No. 14/956,724, Preliminary Amendment filed Dec. 7, 2015", 8 pgs.

"U.S. Appl. No. 14/983,108, Preliminary Amendment filed Dec. 30, 2015", 7 pgs.

"U.S. Appl. No. 14/983,747, Preliminary Amendment filed Jan. 4, 2016", 5 pgs.

"European Application Serial No. 10727548.9, Response filed Mar. 19, 2015 to Examination Notification Art. 94(3) mailed Sep. 18, 2014", 23 pgs.

"European Application Serial No. 11707316.3, Office Action mailed Nov. 10, 2015", 6 pgs.

"European Application Serial No. 11707316.3, Response filed Jun. 29, 2015 to Examination Notification Art. 94(3) mailed Dec. 17, 2014", 25 pgs.

"European Application Serial No. 12791902.5, Examination Notification Art. 94(3) mailed Aug. 14, 2015", 4 pgs.

"European Application Serial No. 12806211.4, Examination Notification Art. 94(3) mailed Aug. 13, 2015", 5 pgs.

"European Application Serial No. 13818131.8, Office Action mailed Jul. 28, 2015", 2 pgs.

"European Application Serial No. 14716173.1, Office Action mailed Nov. 5, 2015", 2 pgs.

"International Application Serial No. PCT/US2013/075989, International Preliminary Report on Patentability mailed Jul. 2, 2015", 10 pgs.

"International Application Serial No. PCT/US2014/026413, International Preliminary Report on Patentability mailed Sep. 24, 2015", 10 pgs.

Charlton, Timothy, "Ziptight™ Fixation System Featuring Zip Loop™ Technology. Ankle Syndesmosis. Surgical Protocol", Biomet Sports® Medicine brochure, (Jun. 15, 2011), 8 pgs.

* cited by examiner



FIG. 1
(prior art)

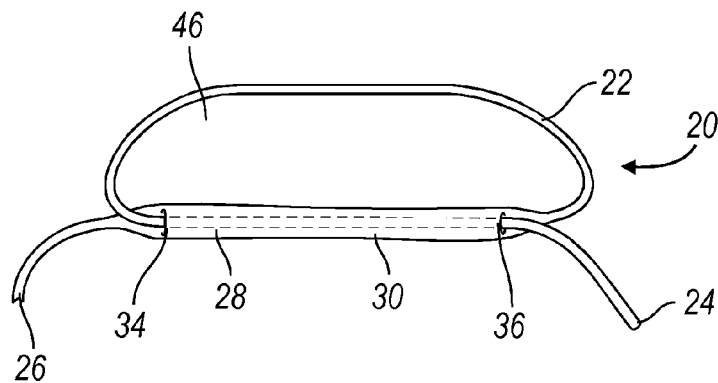


FIG. 2A

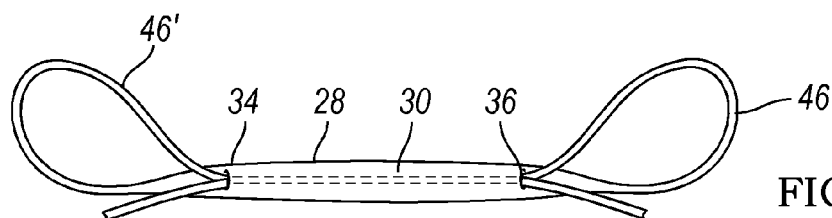
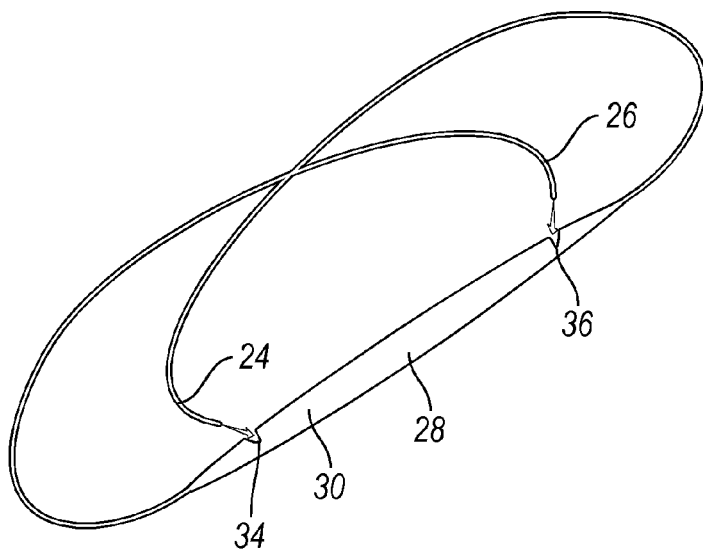
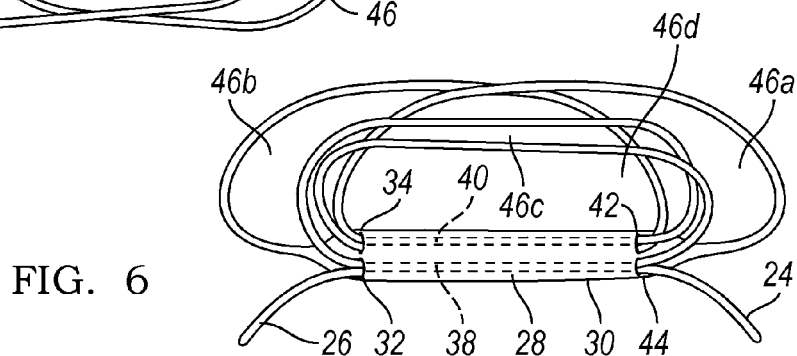
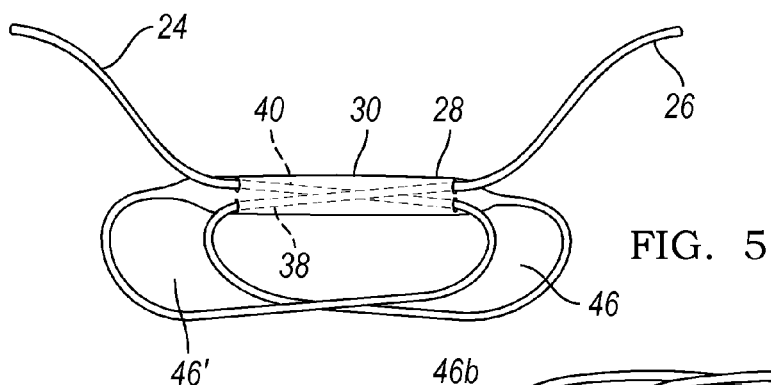
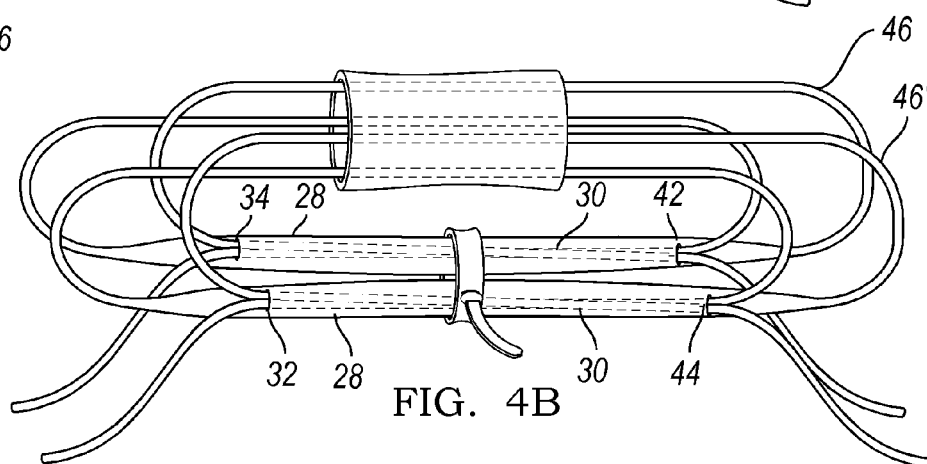
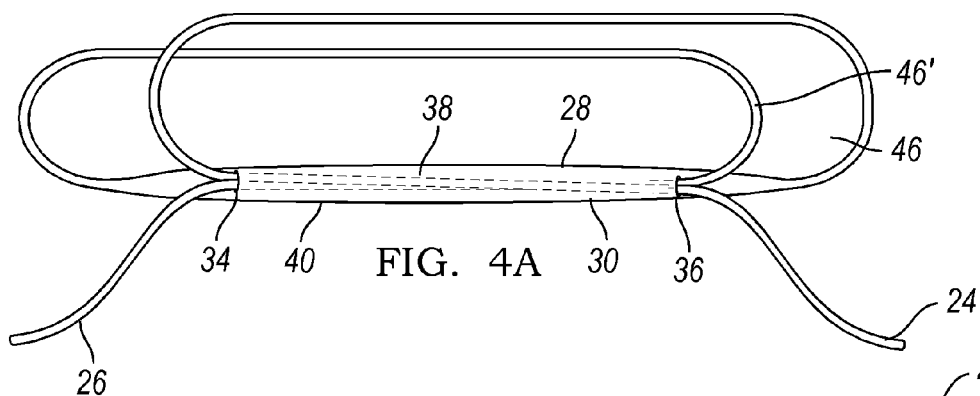


FIG. 2B

FIG. 3





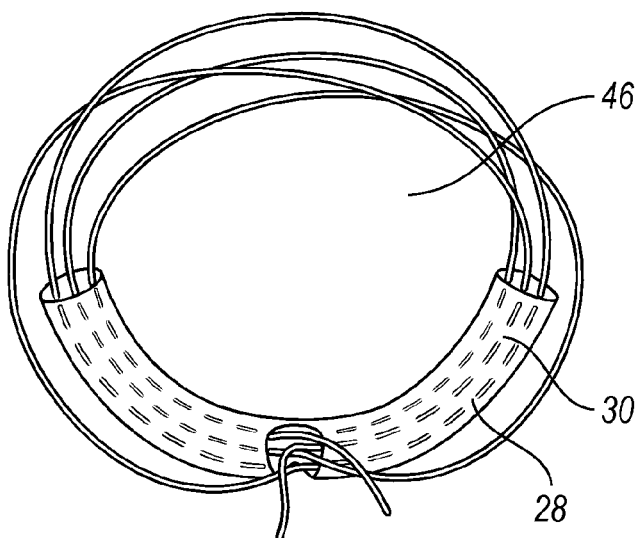


FIG. 7

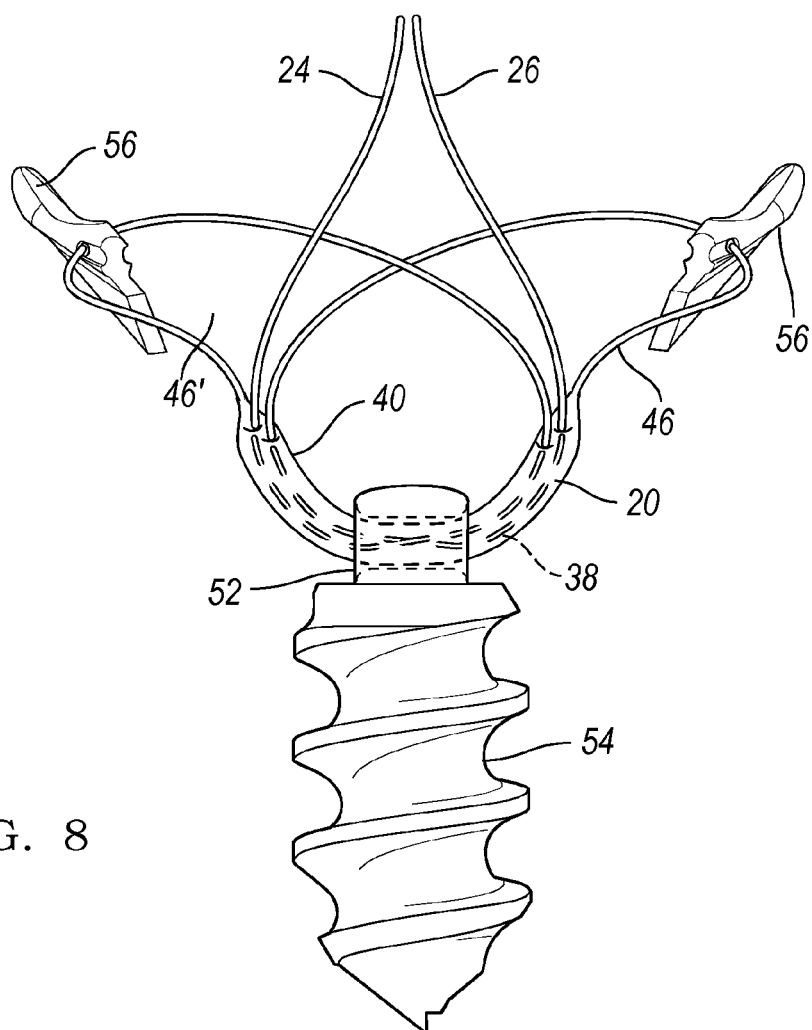
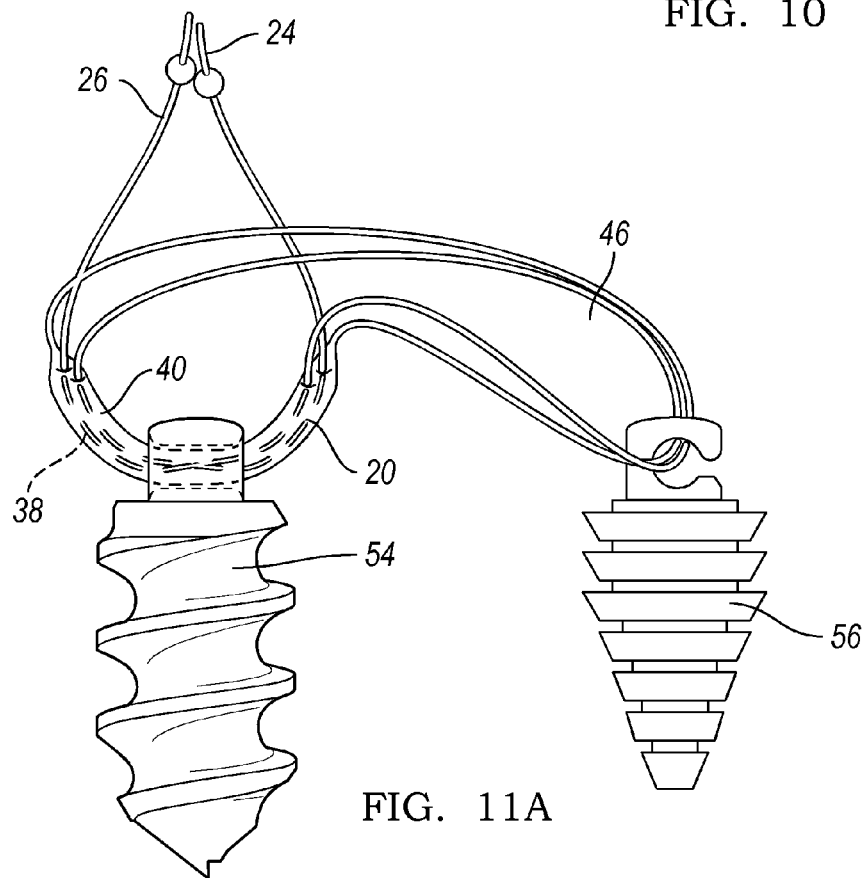
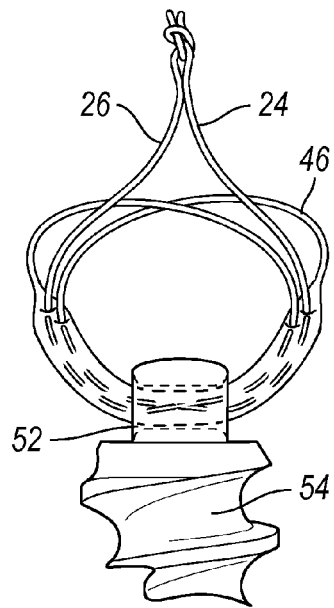
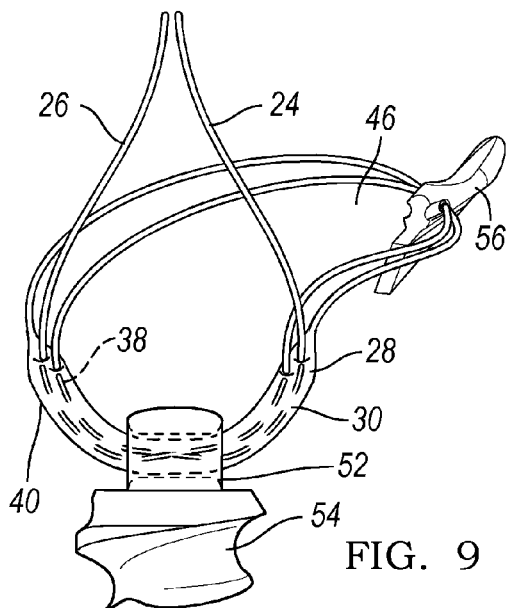


FIG. 8



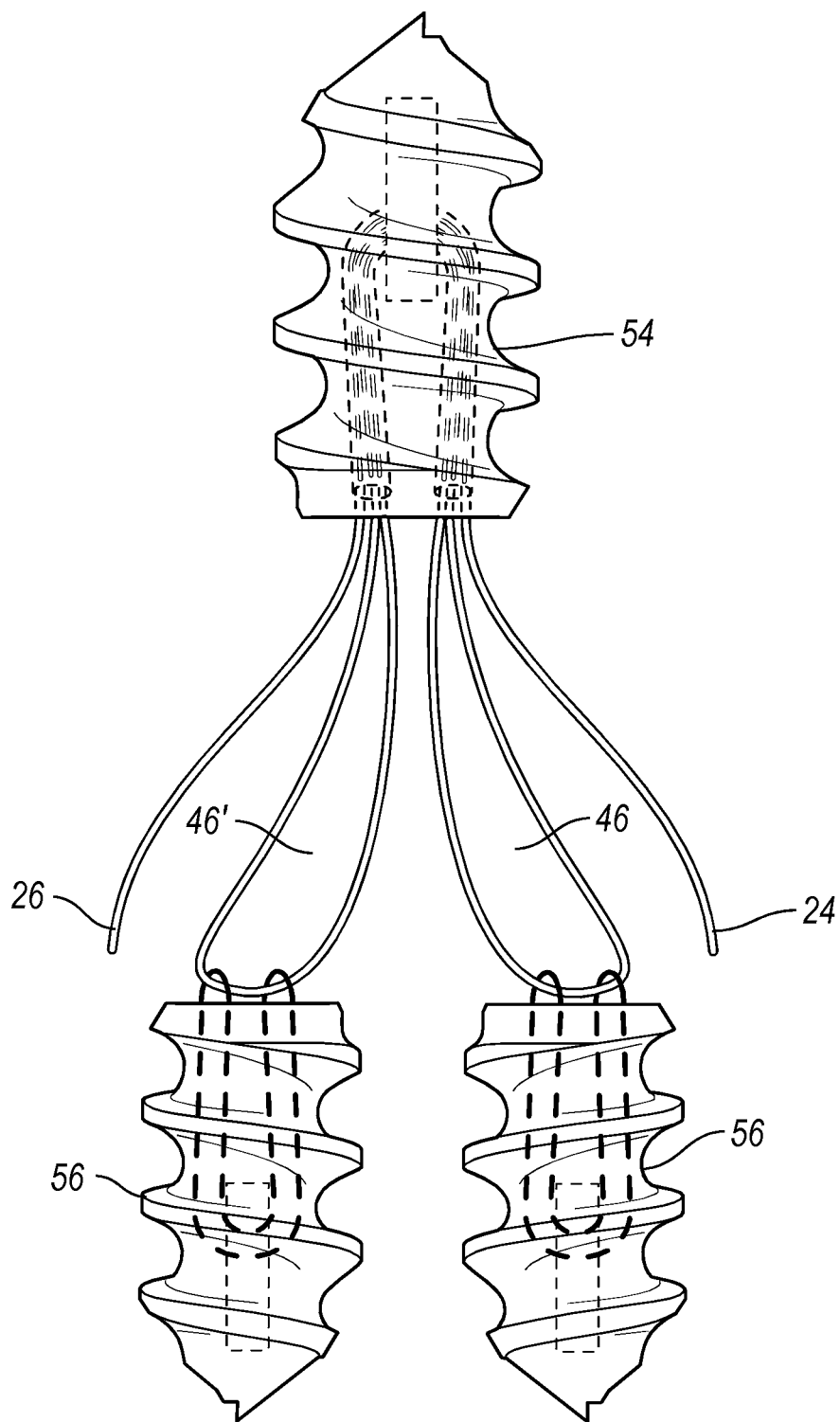


FIG. 11B

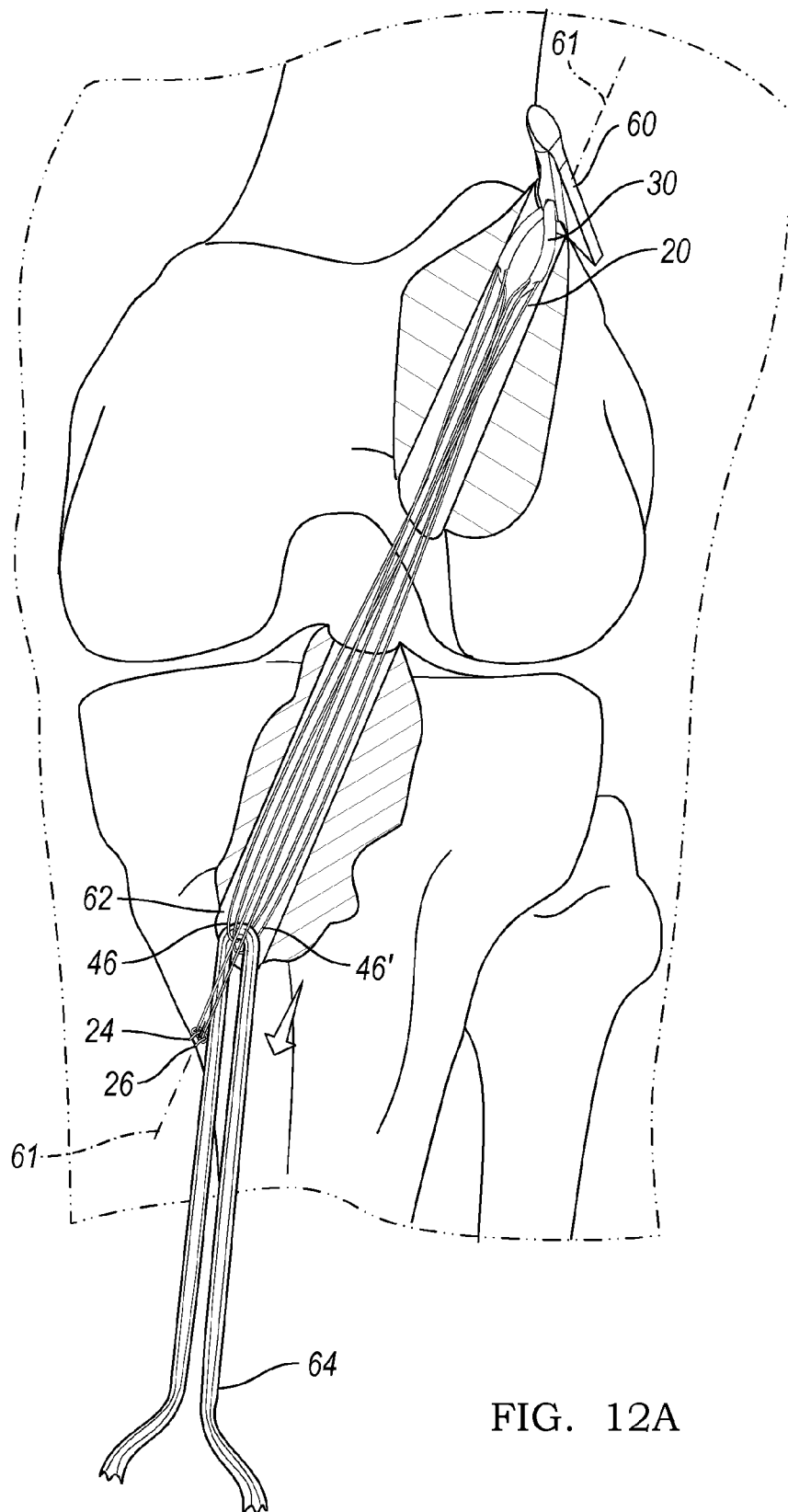


FIG. 12A

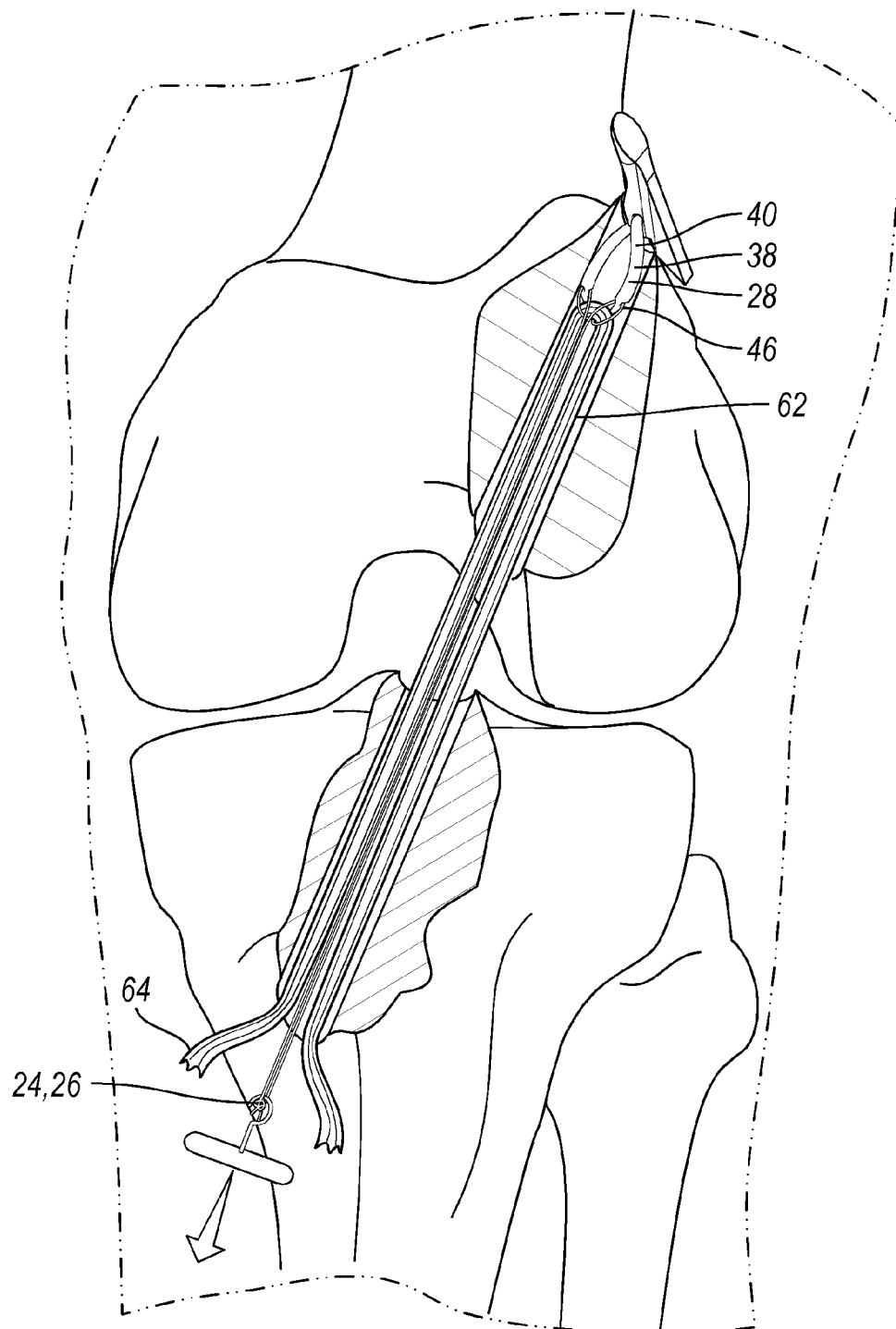


FIG. 12B

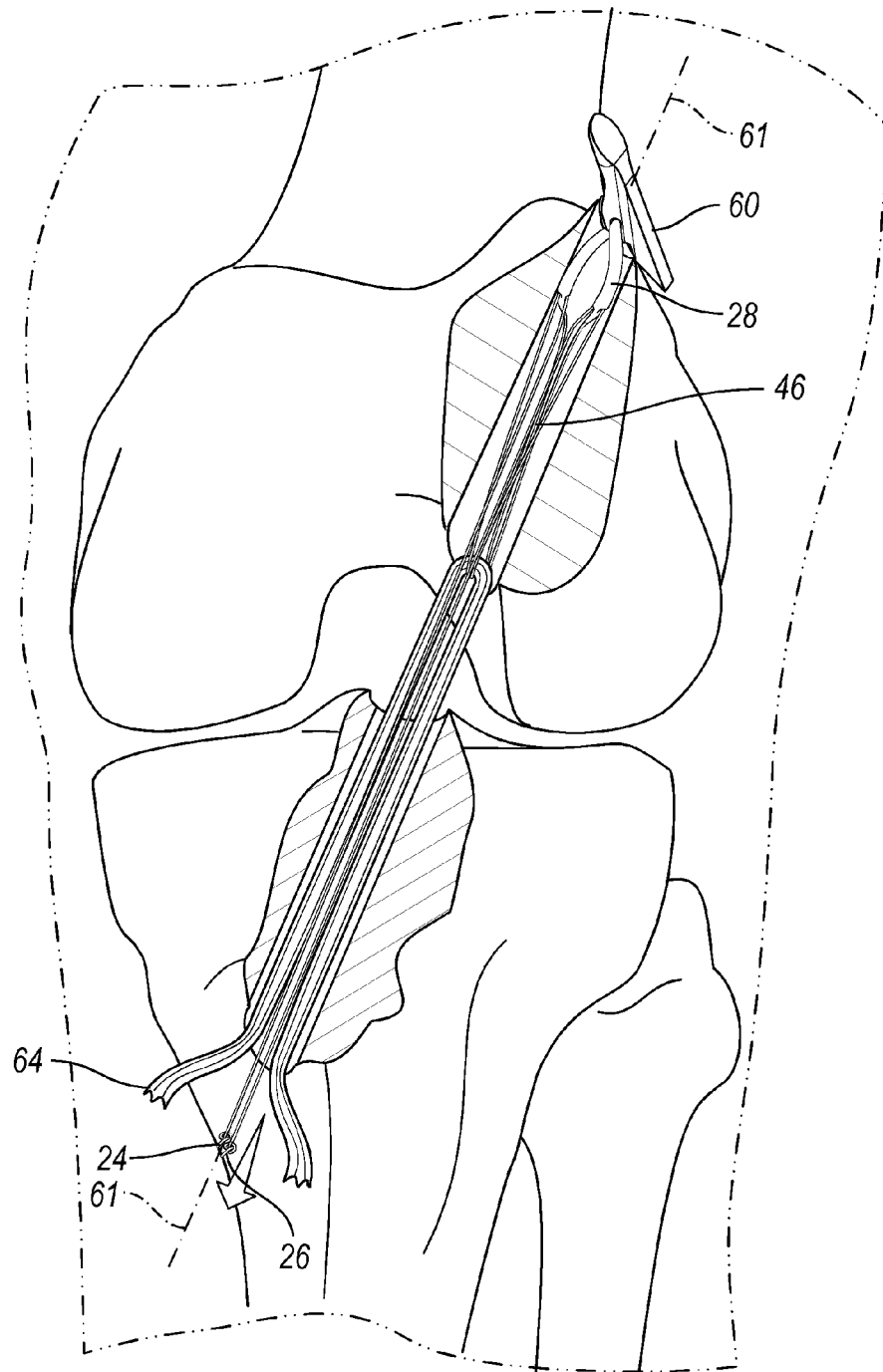


FIG. 12C

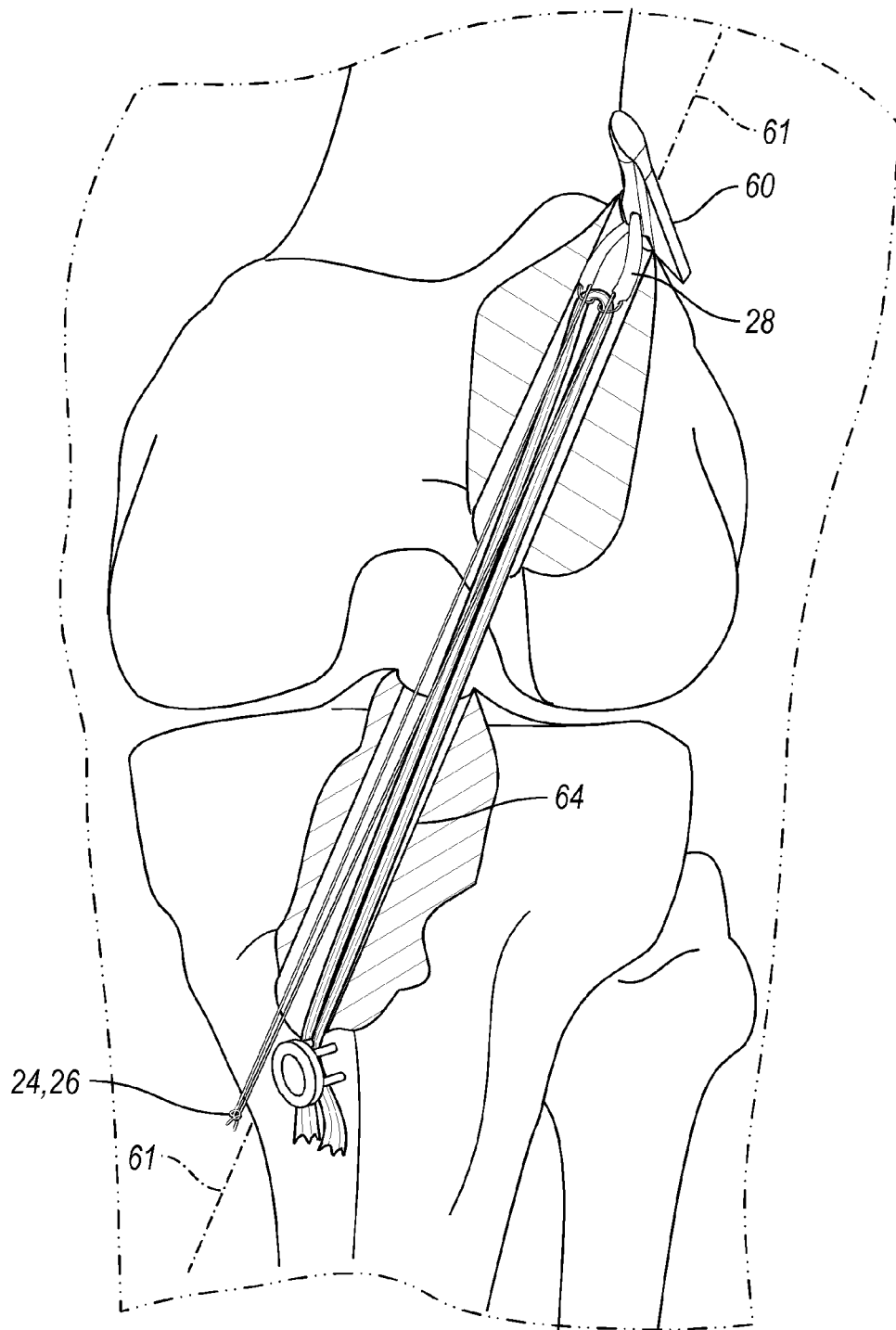
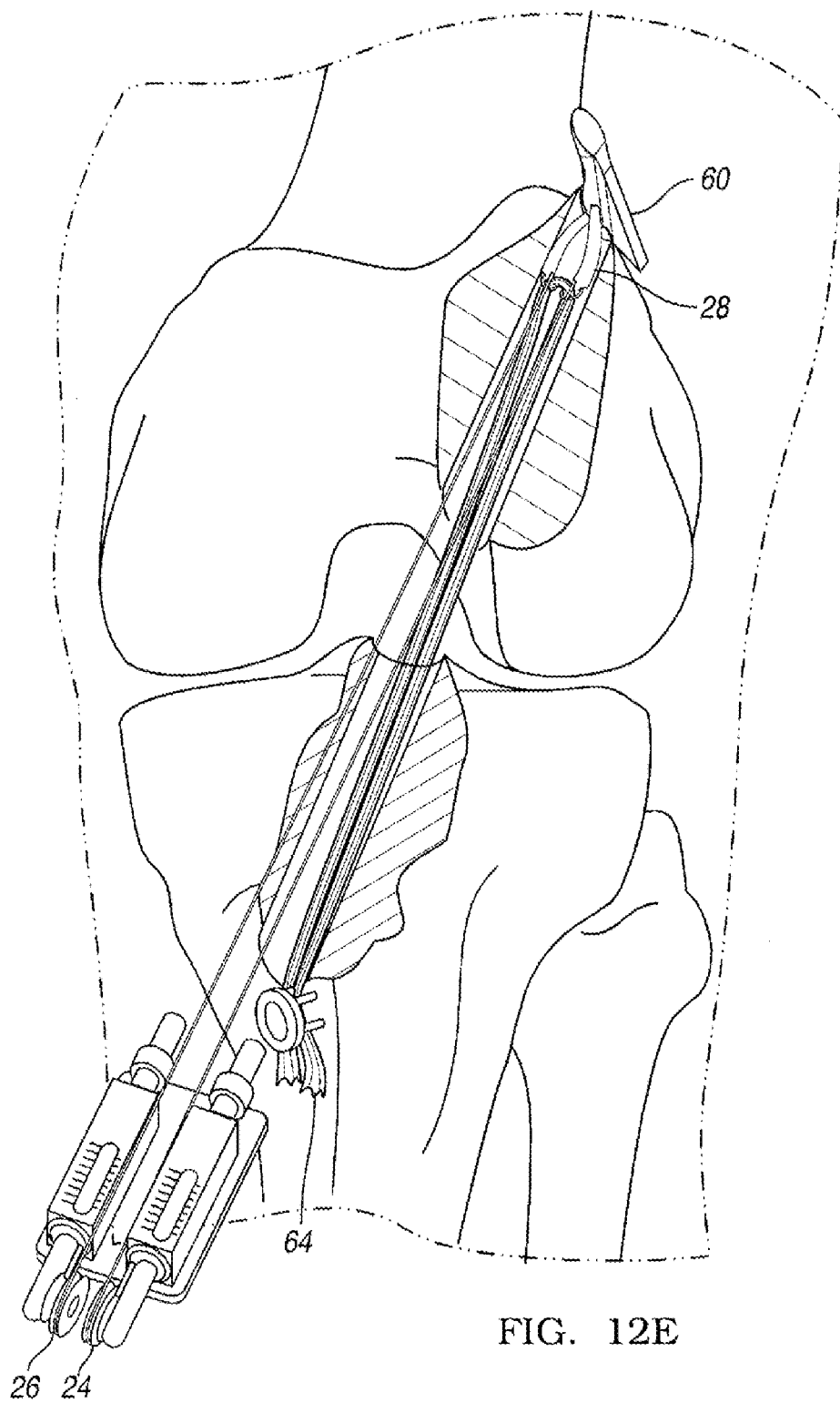
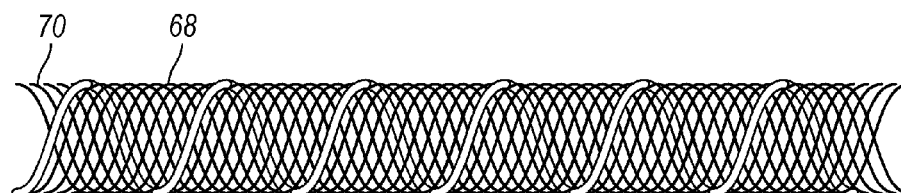
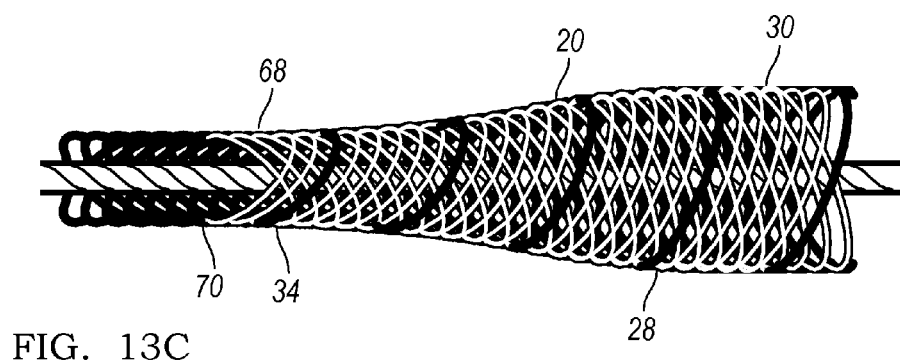
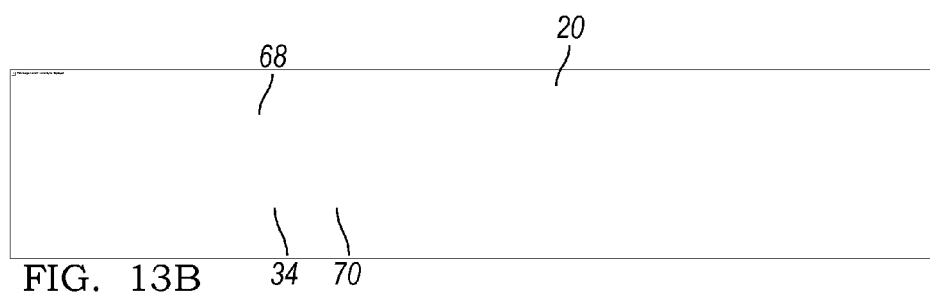
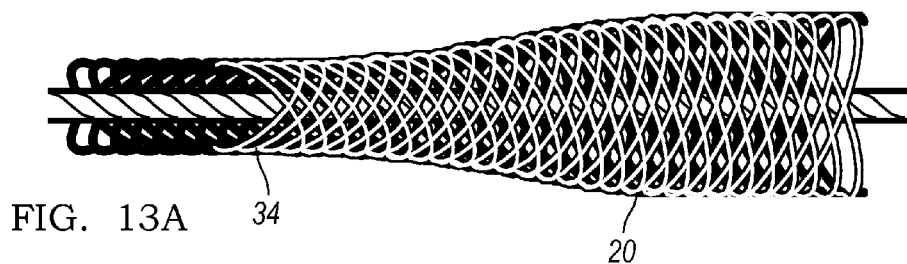


FIG. 12D





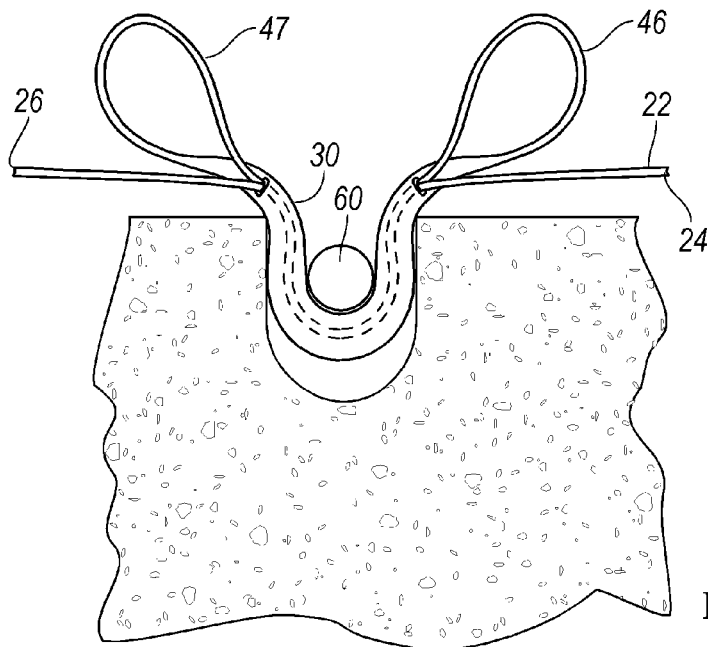


FIG. 14A

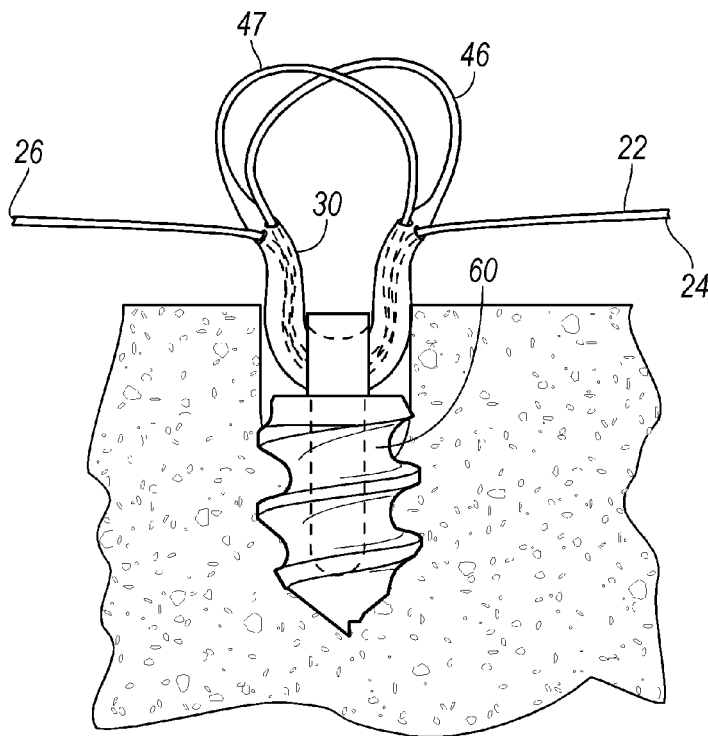


FIG. 14B

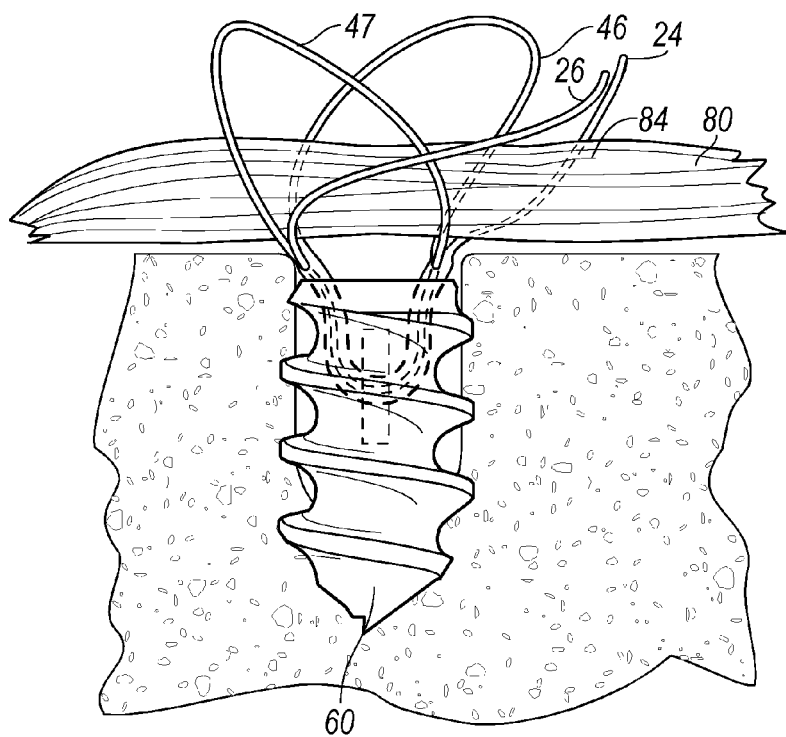


FIG. 15A

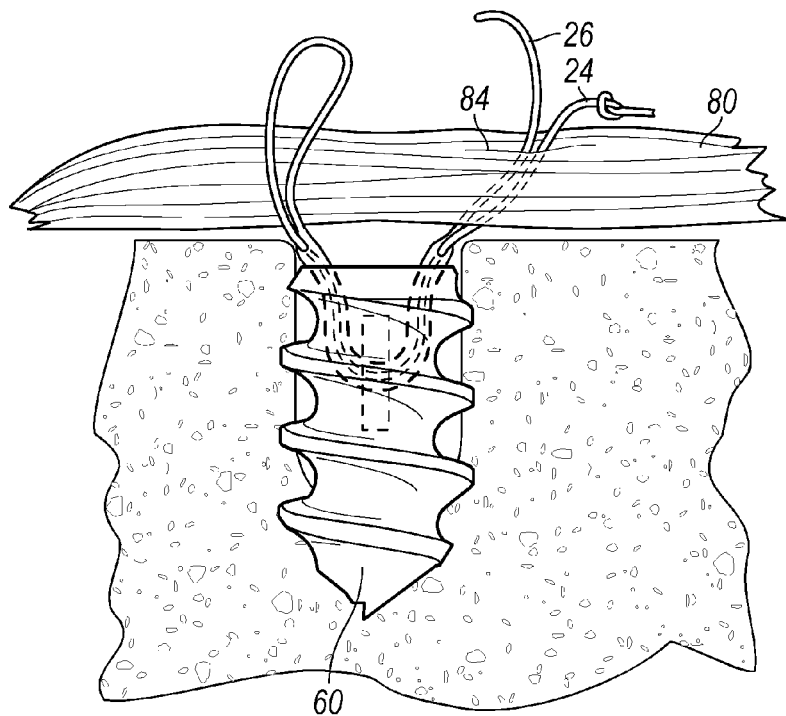


FIG. 15B

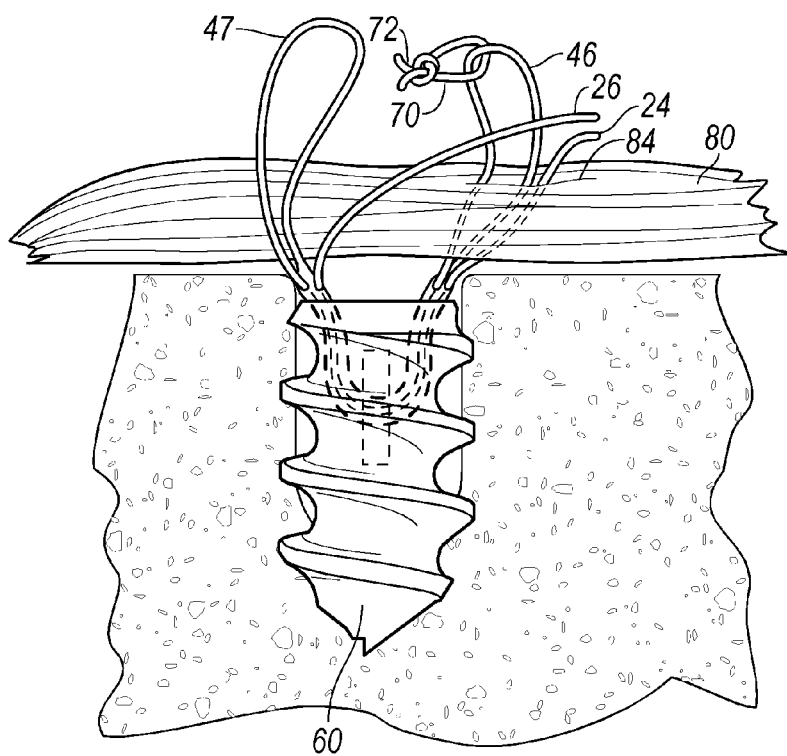


FIG. 15C

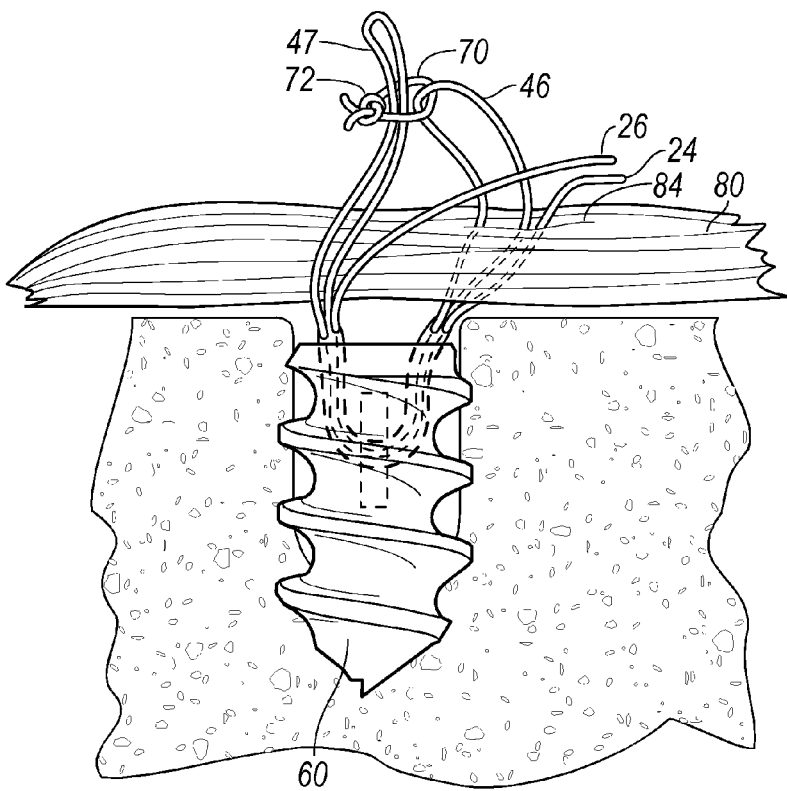


FIG. 15D

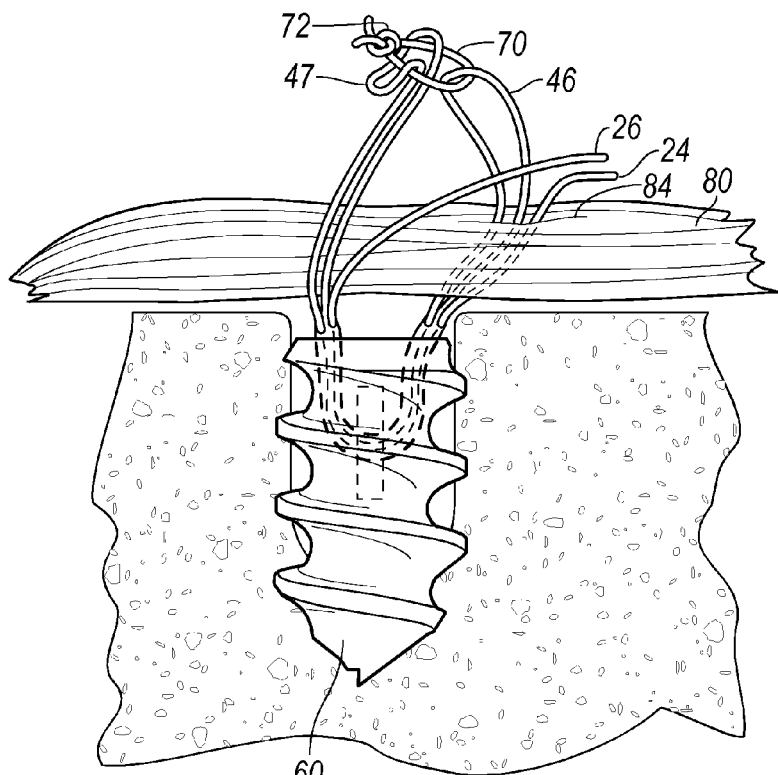


FIG. 15E

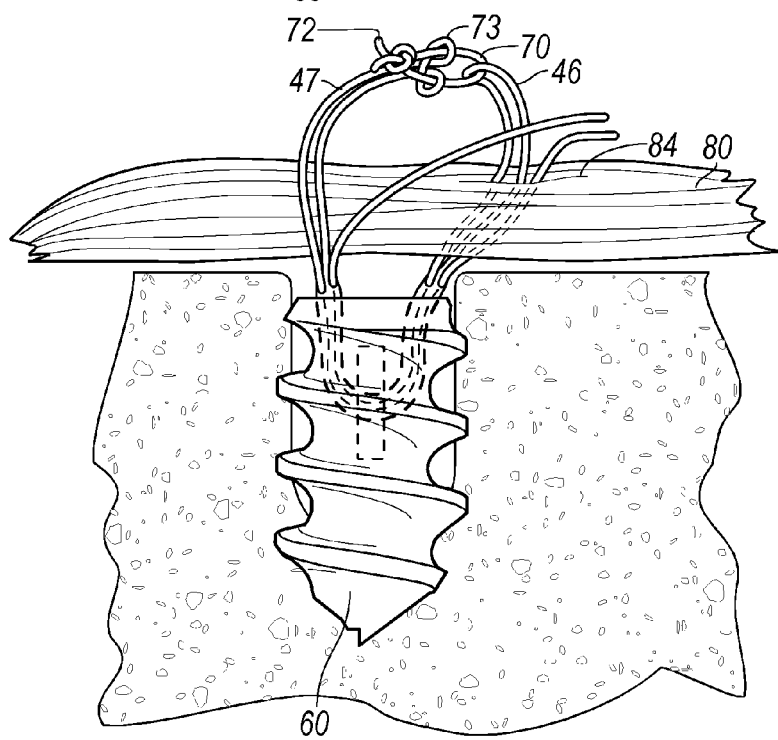


FIG. 15F

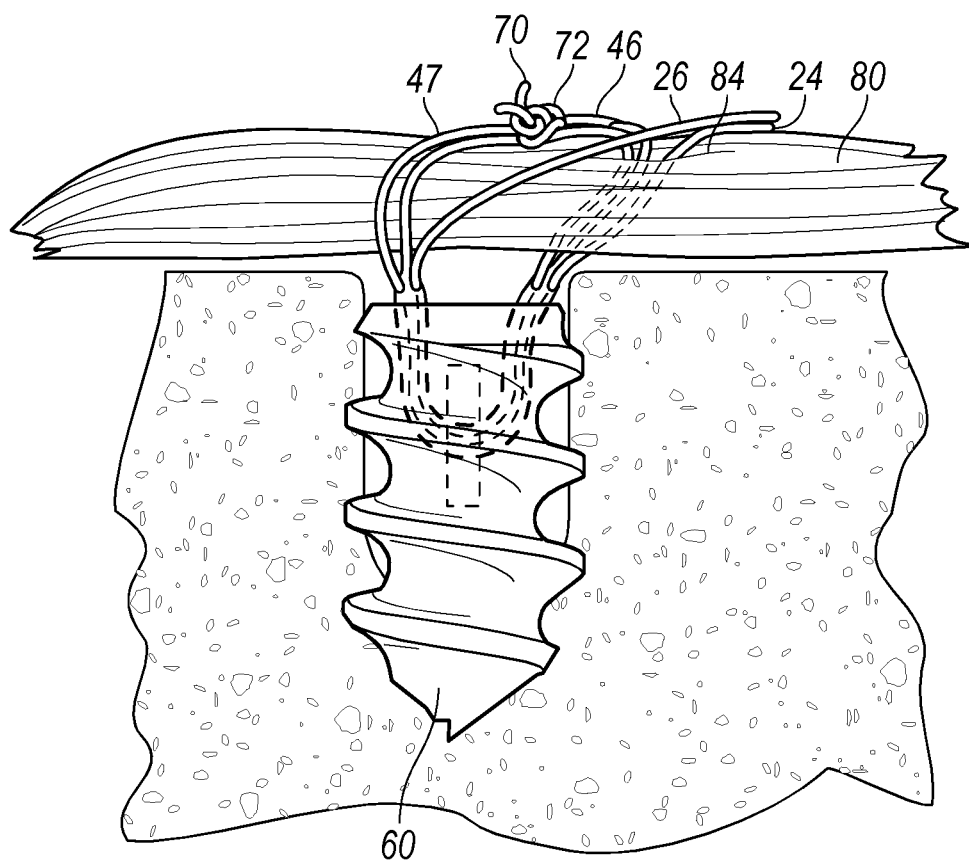


FIG. 15G

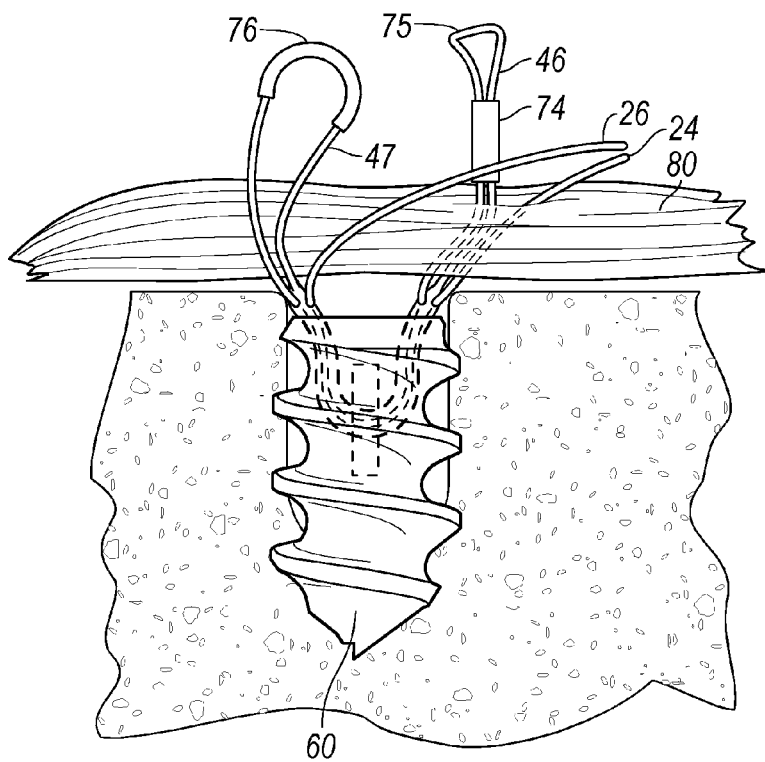


FIG. 16A

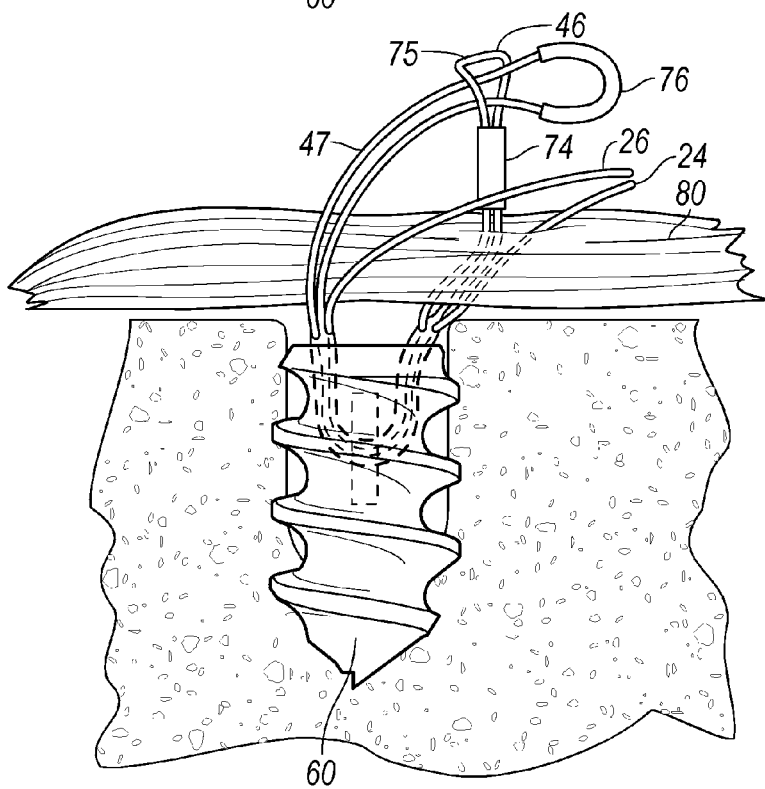


FIG. 16B

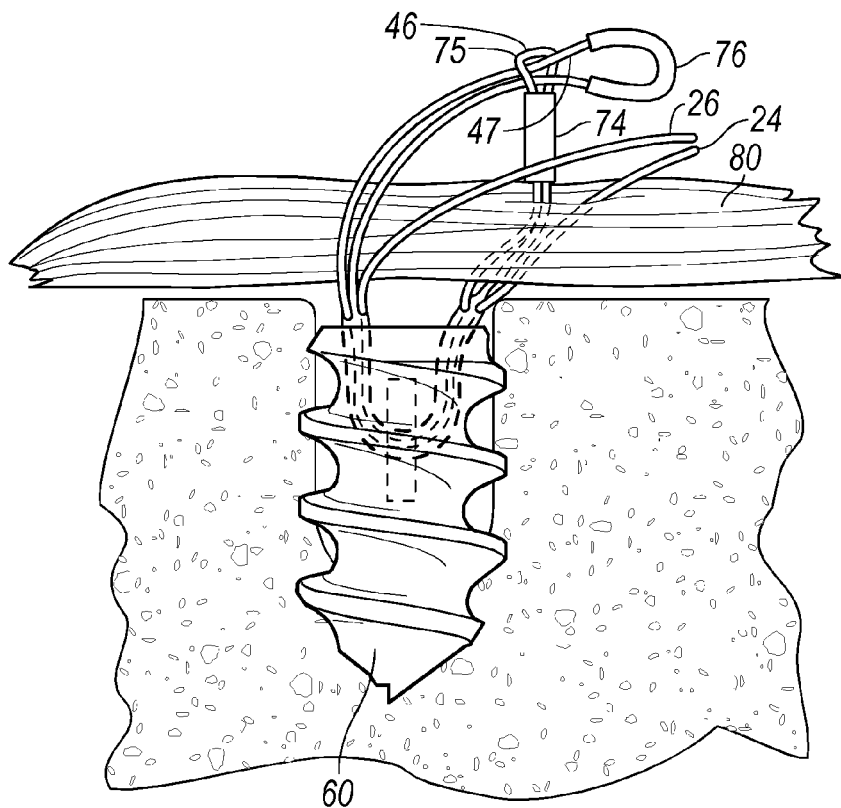


FIG. 16C

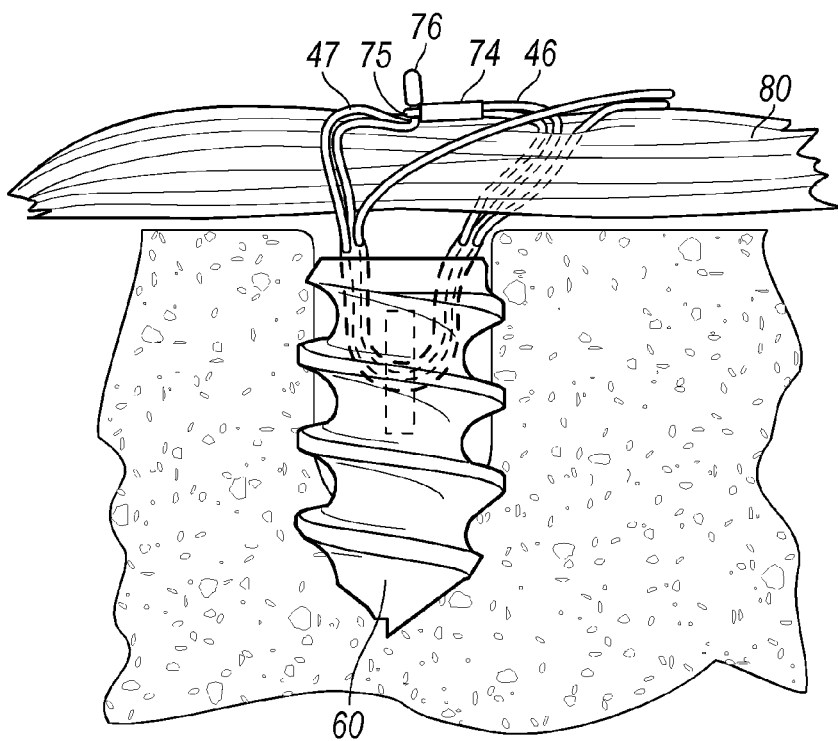


FIG. 16D

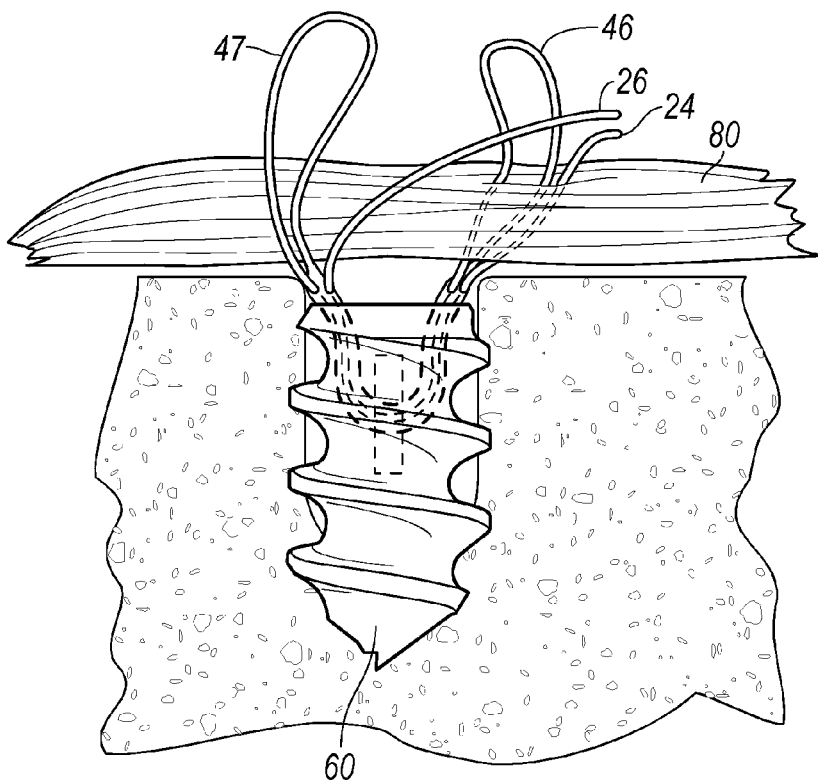


FIG. 17A

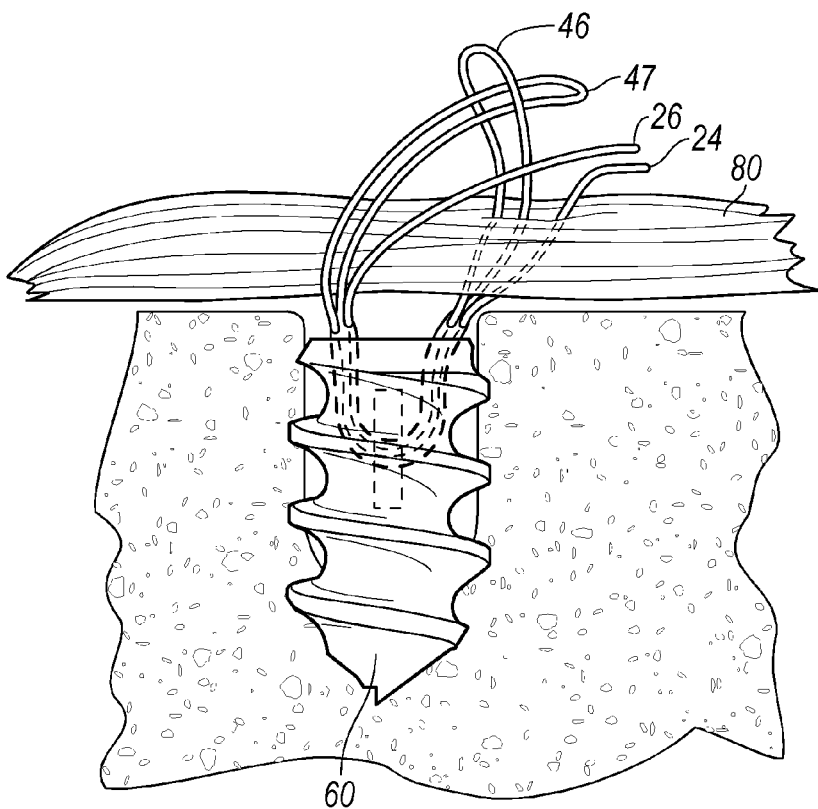


FIG. 17B

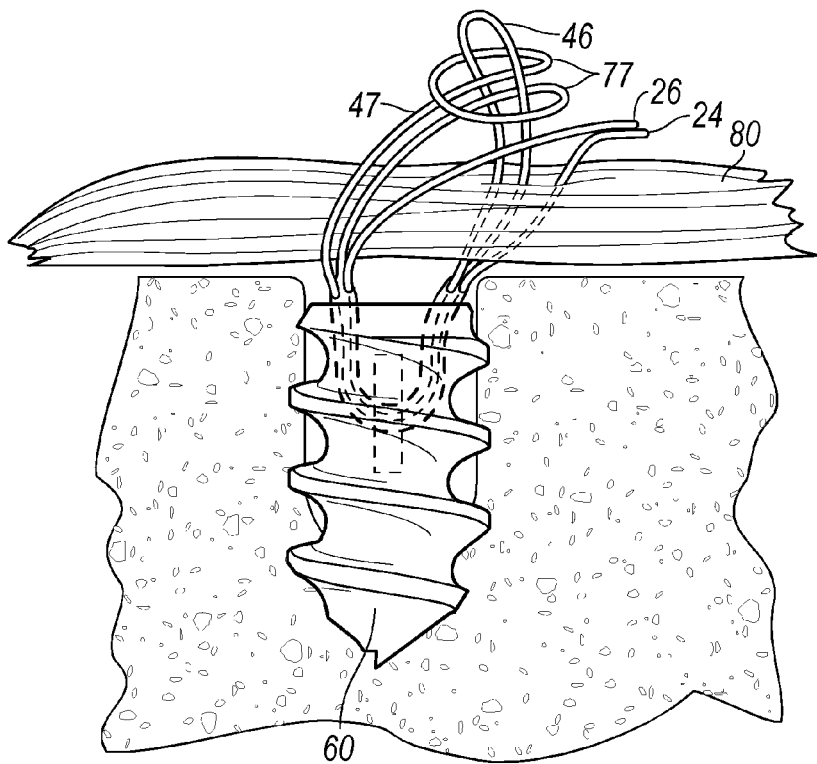


FIG. 17C

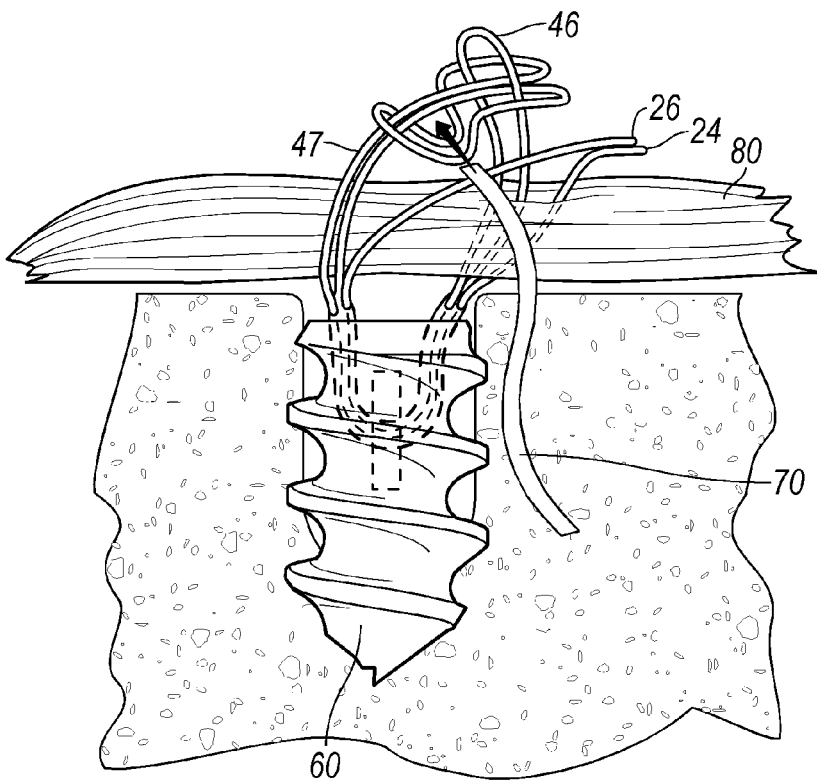


FIG. 17D

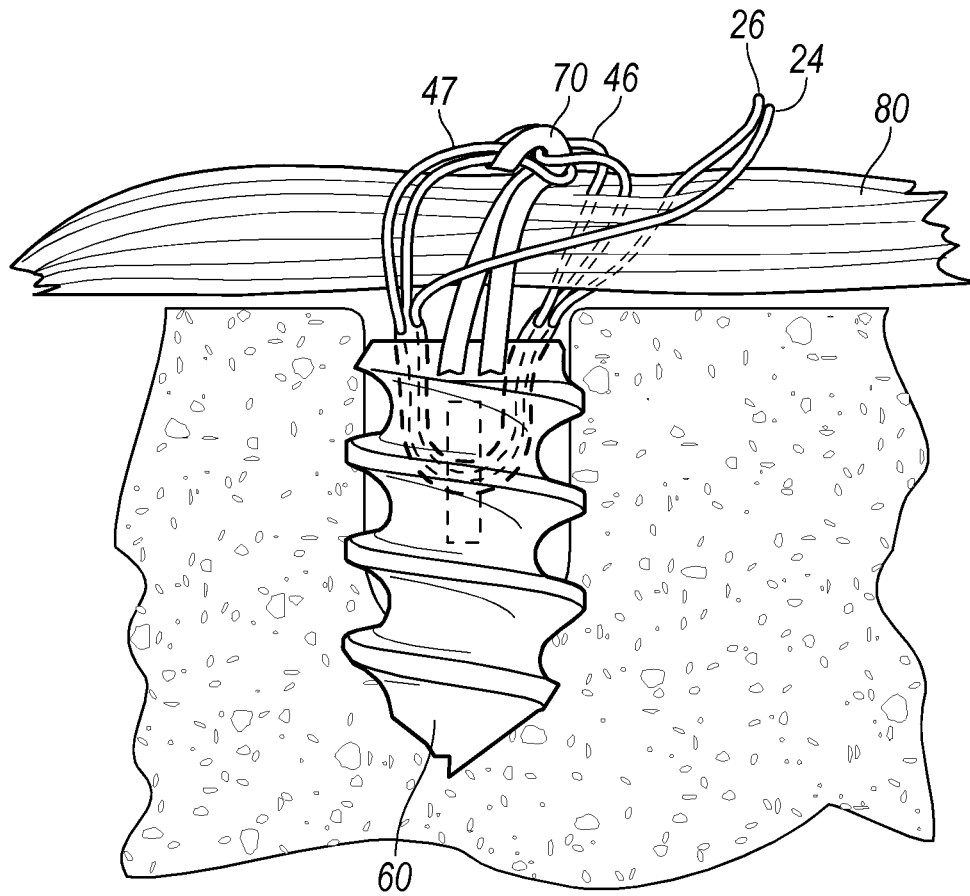


FIG. 17E

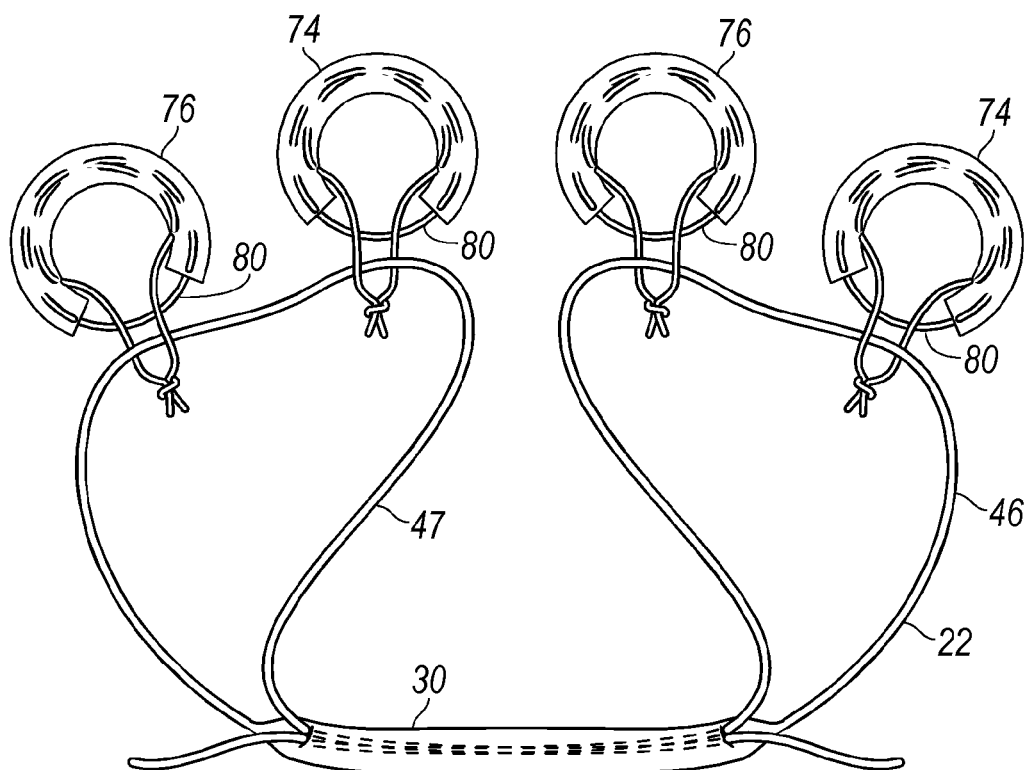


FIG. 18A

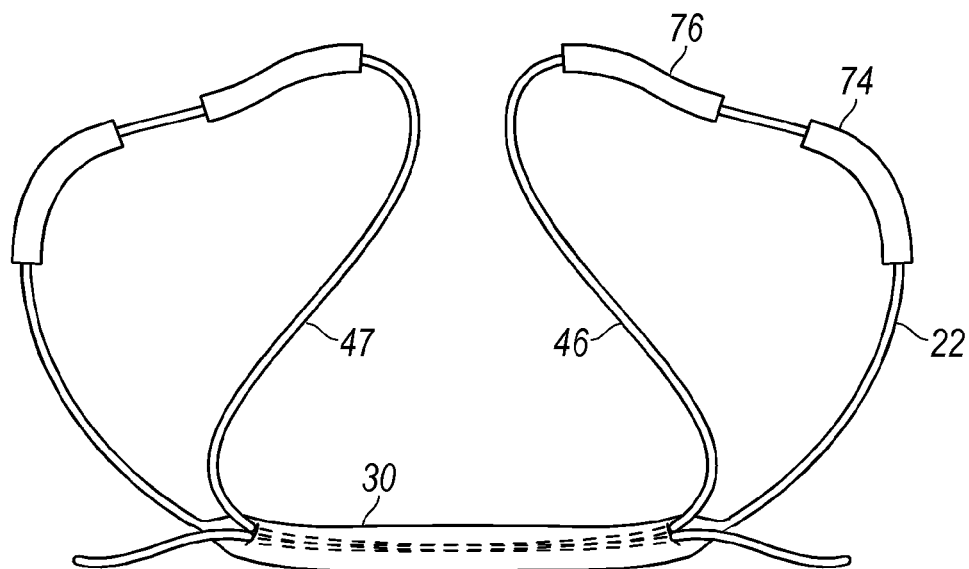


FIG. 18B

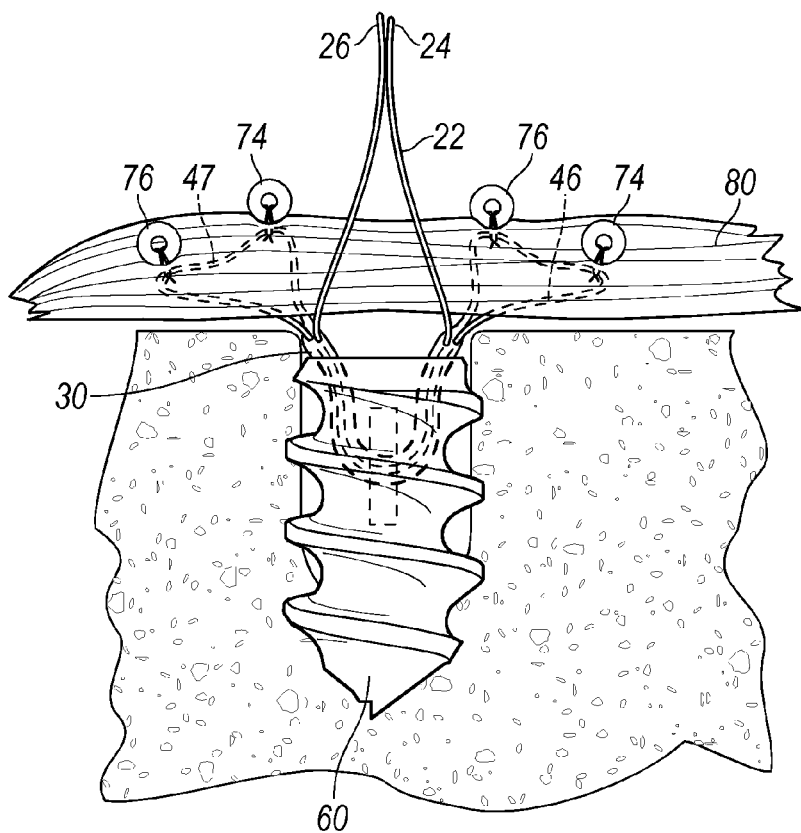


FIG. 18C

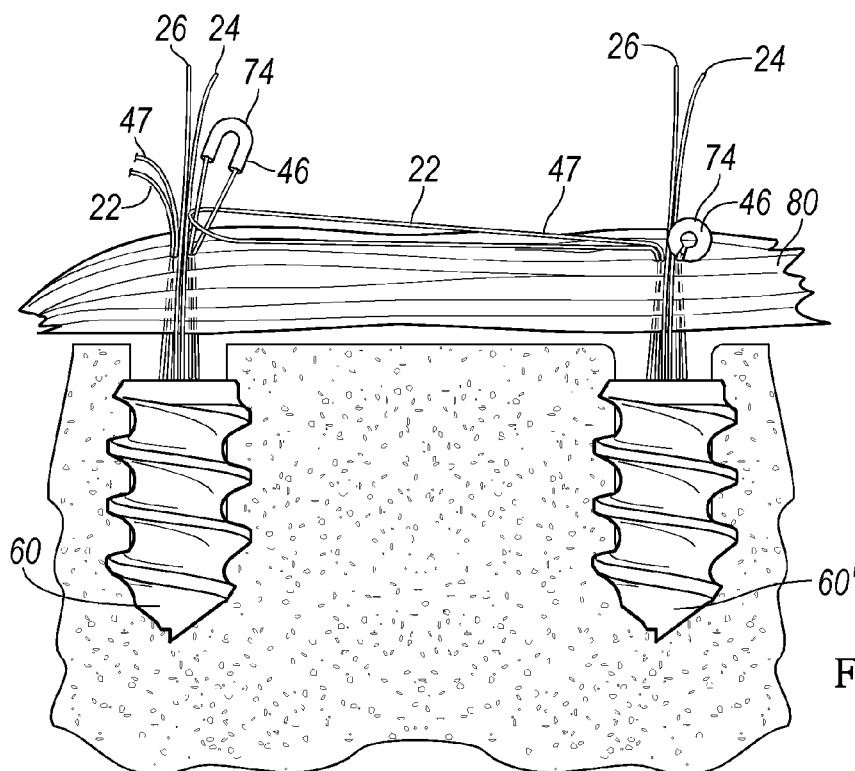


FIG. 19A

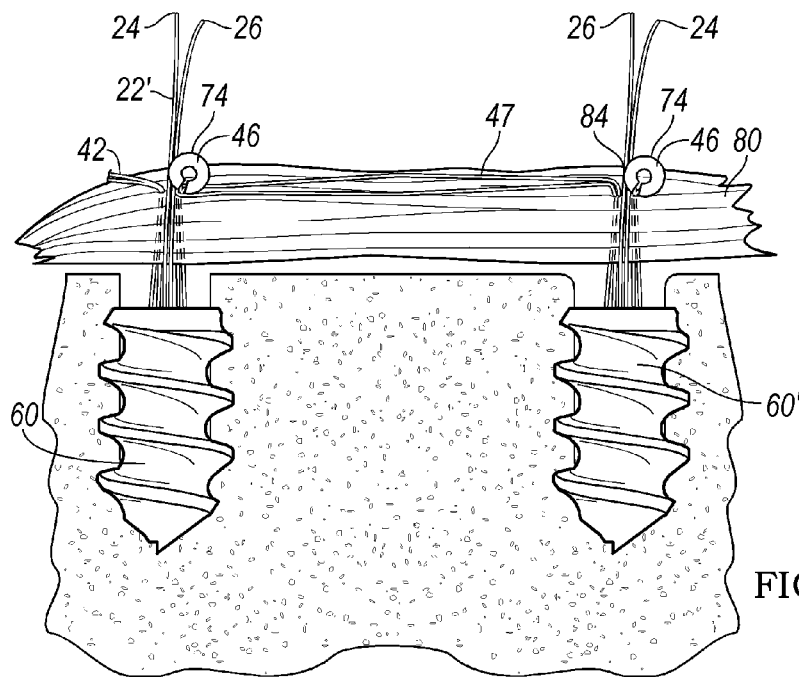


FIG. 19B

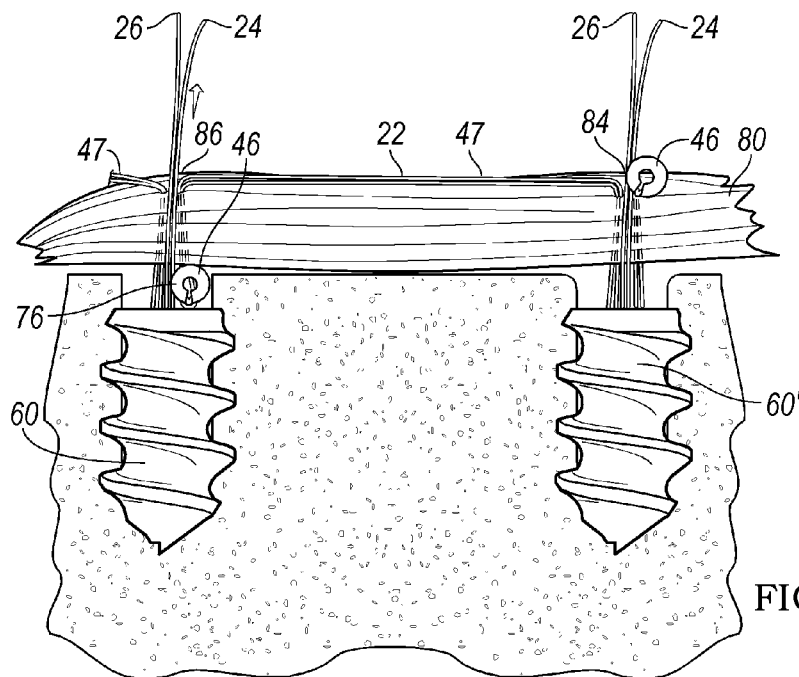


FIG. 19C

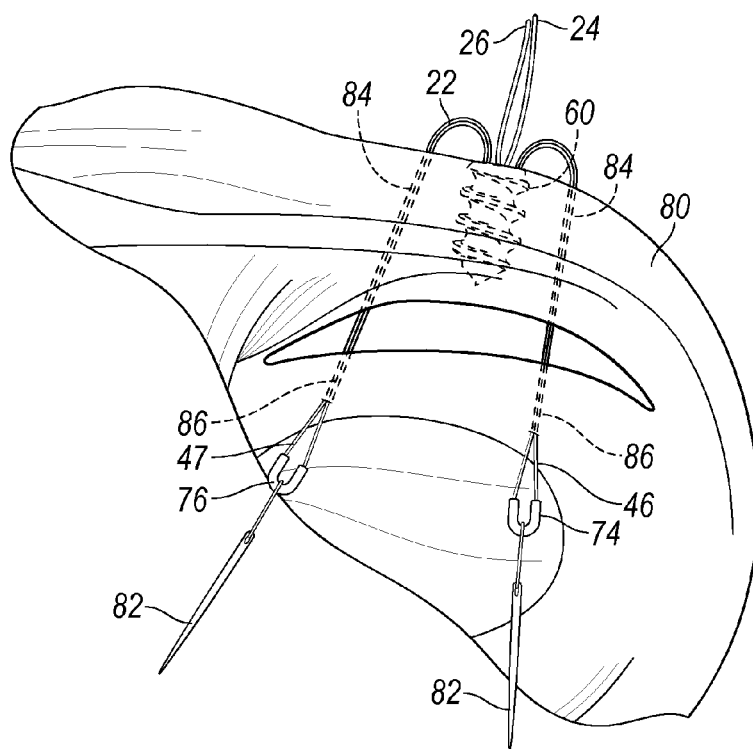


FIG. 20A

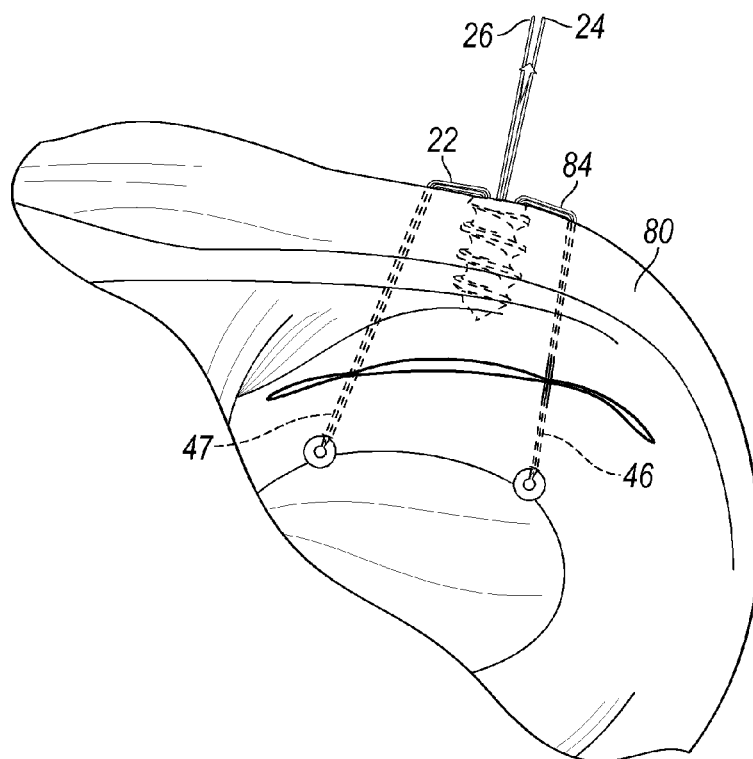


FIG. 20B

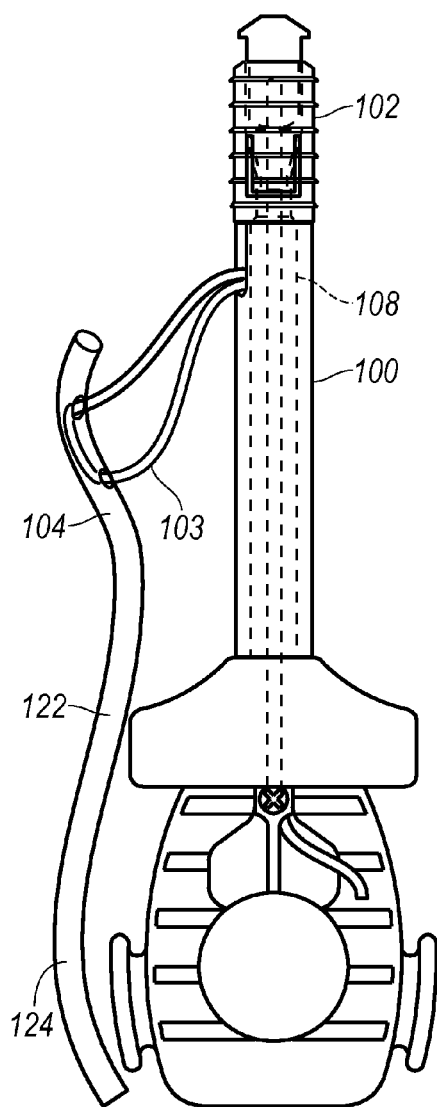


FIG. 21

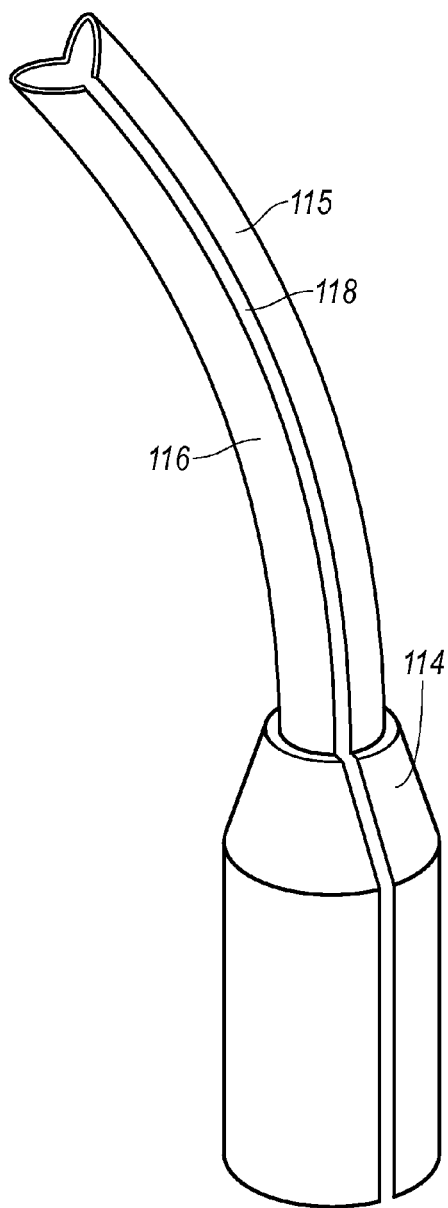


FIG. 22

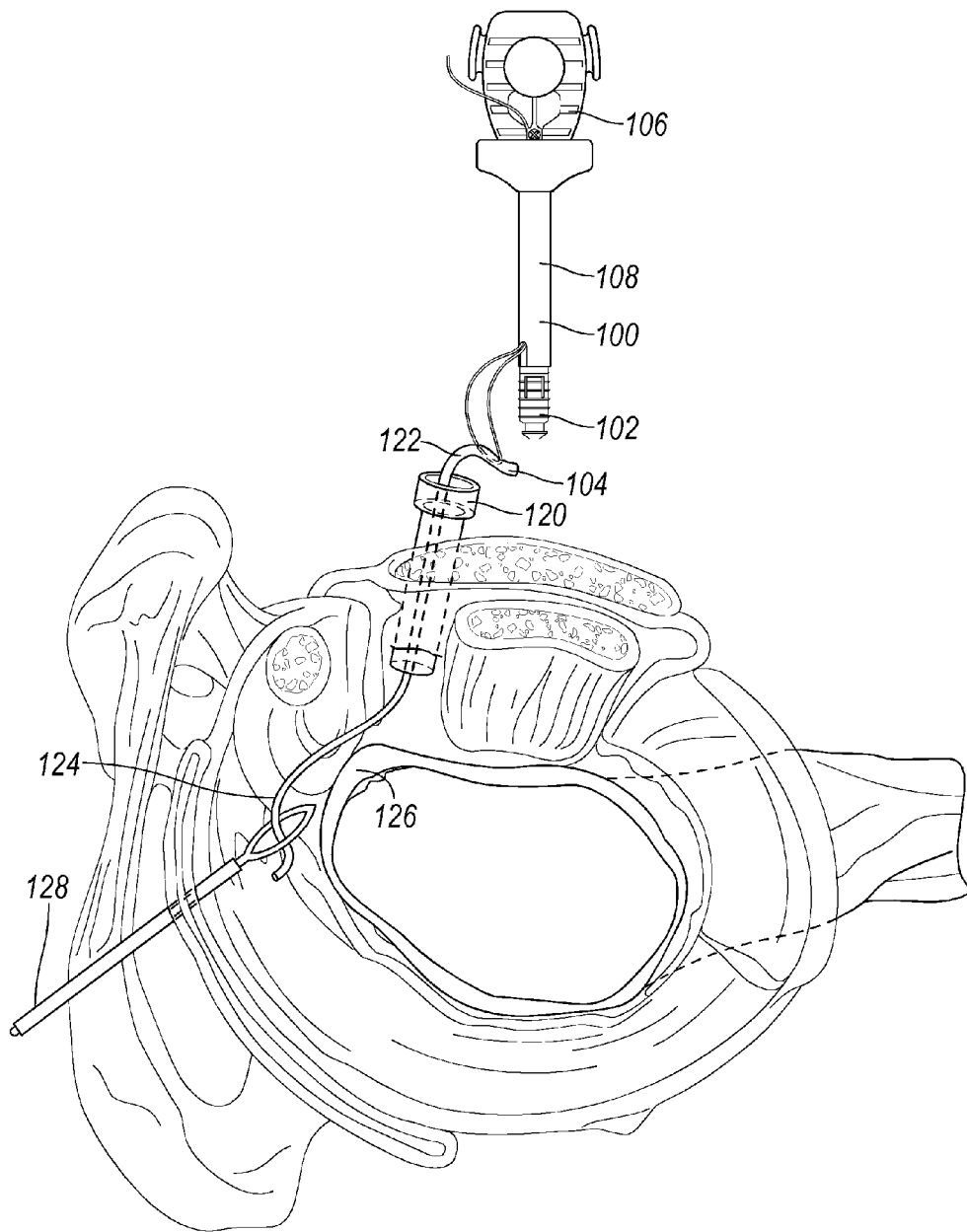


FIG. 23

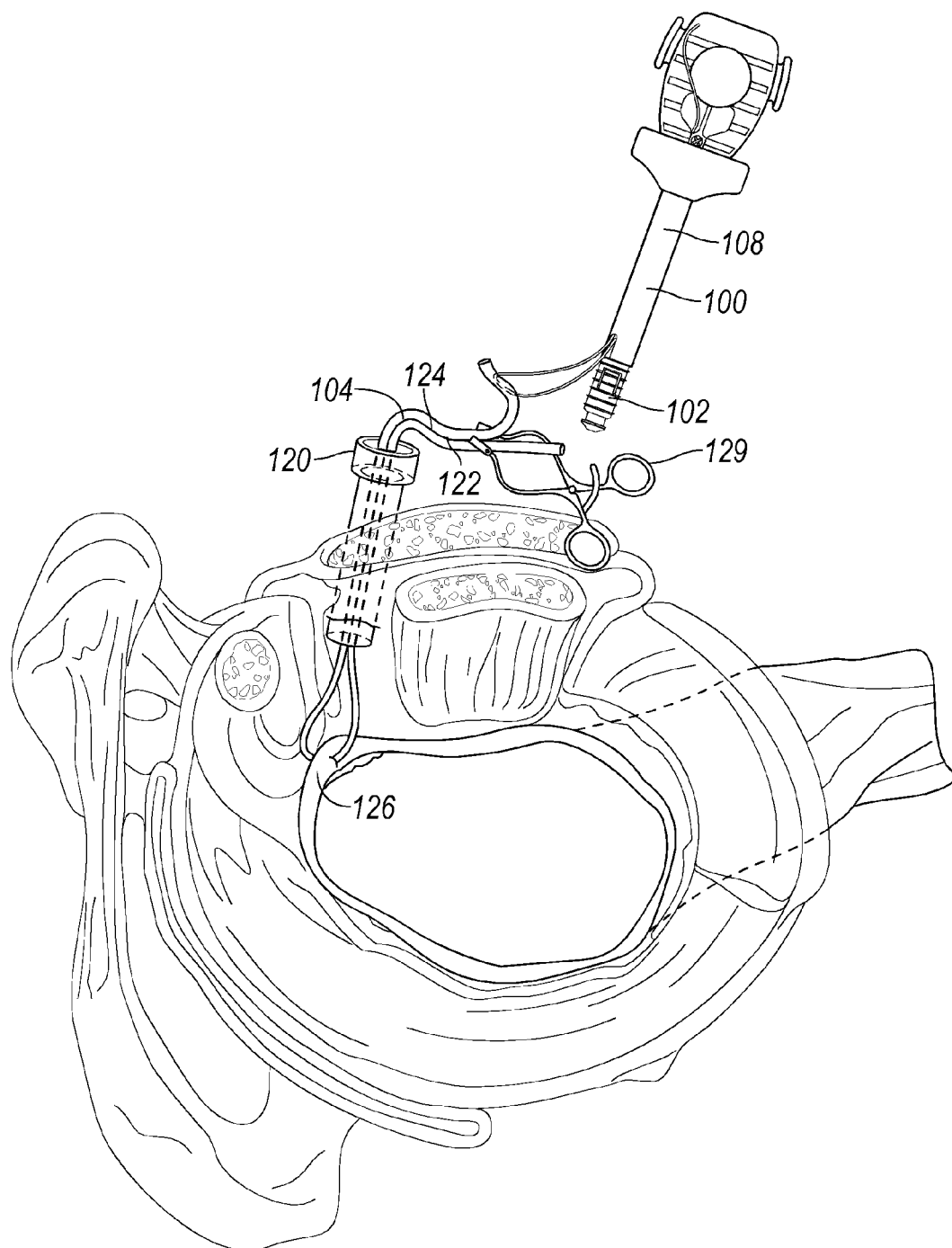


FIG. 24

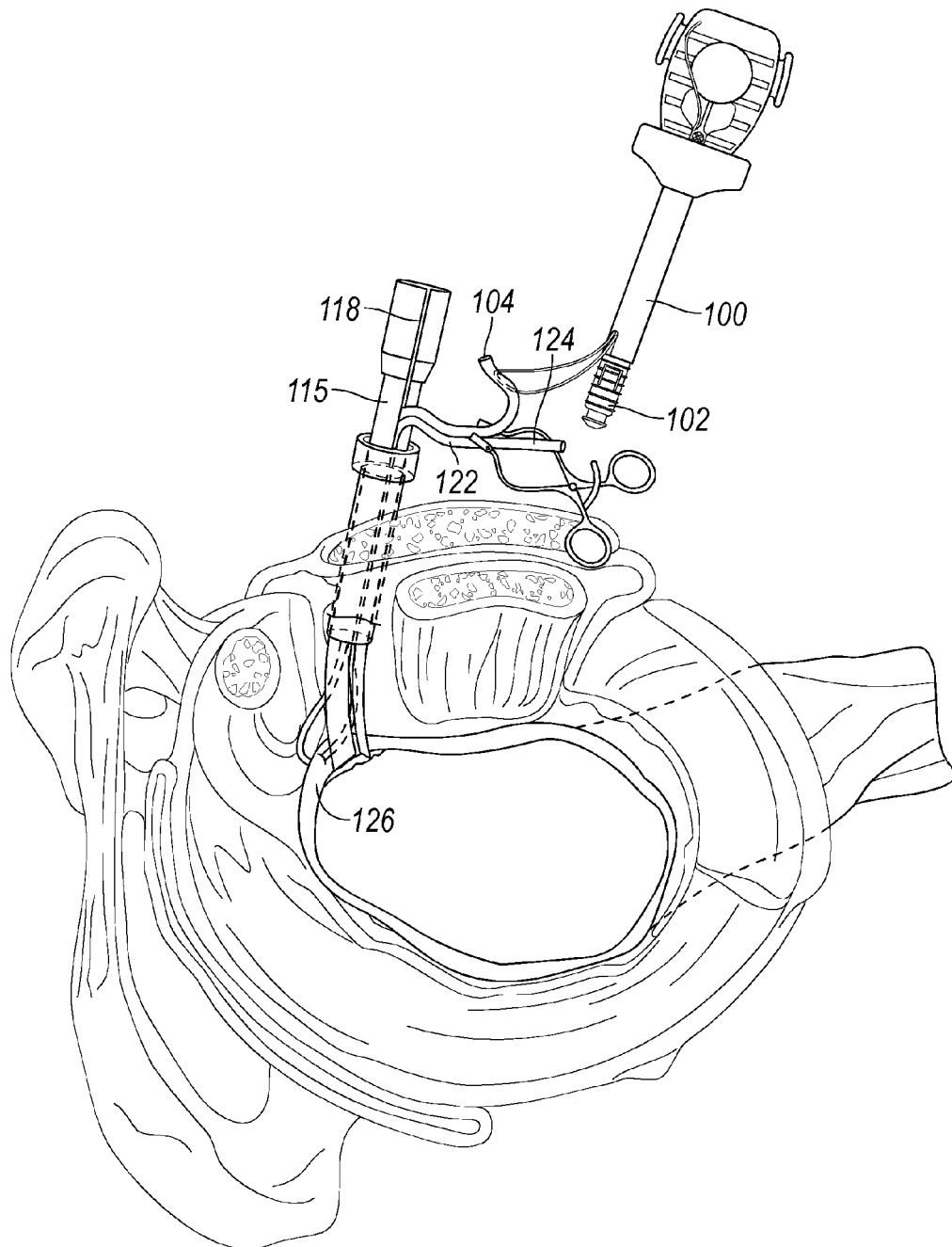


FIG. 25

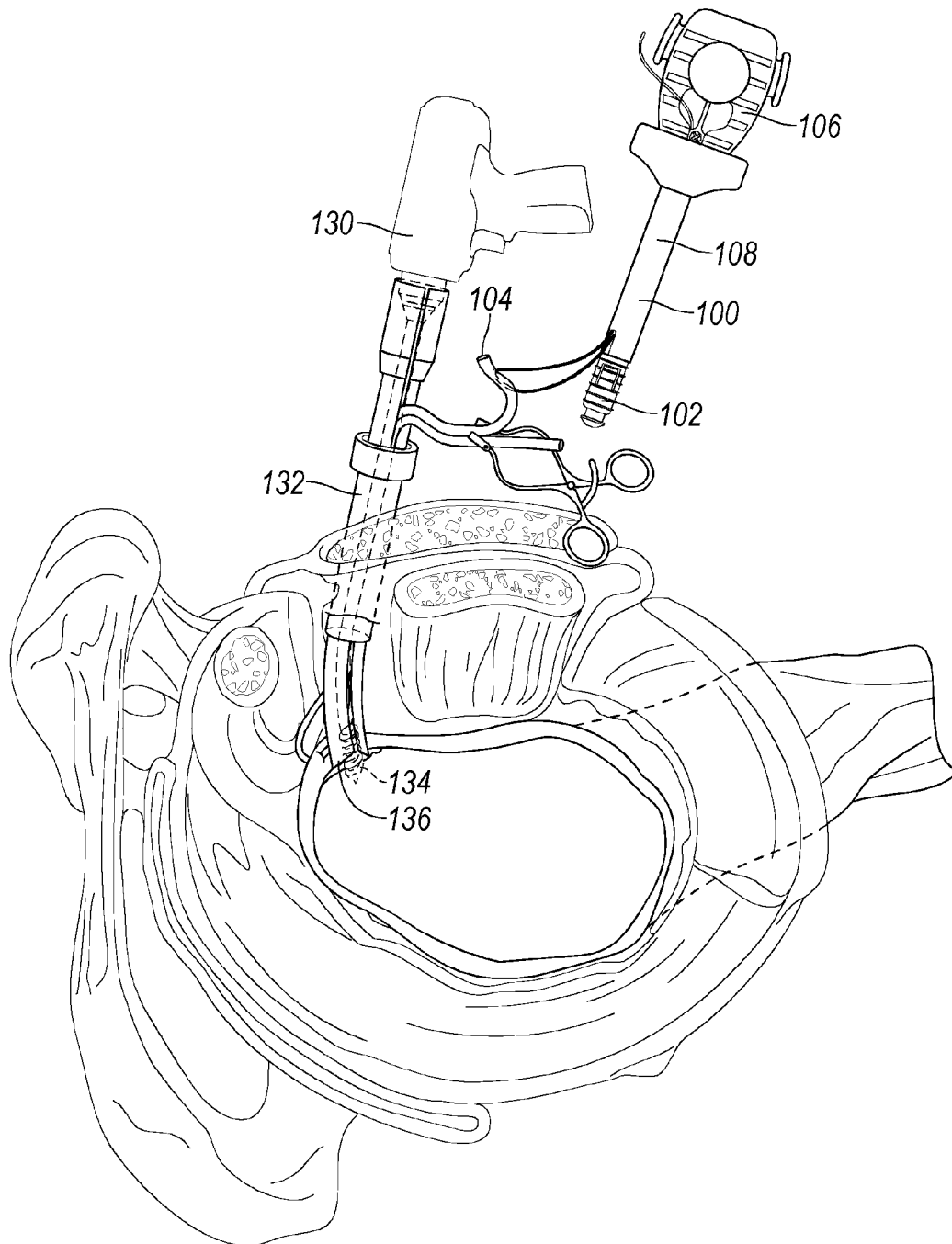


FIG. 26

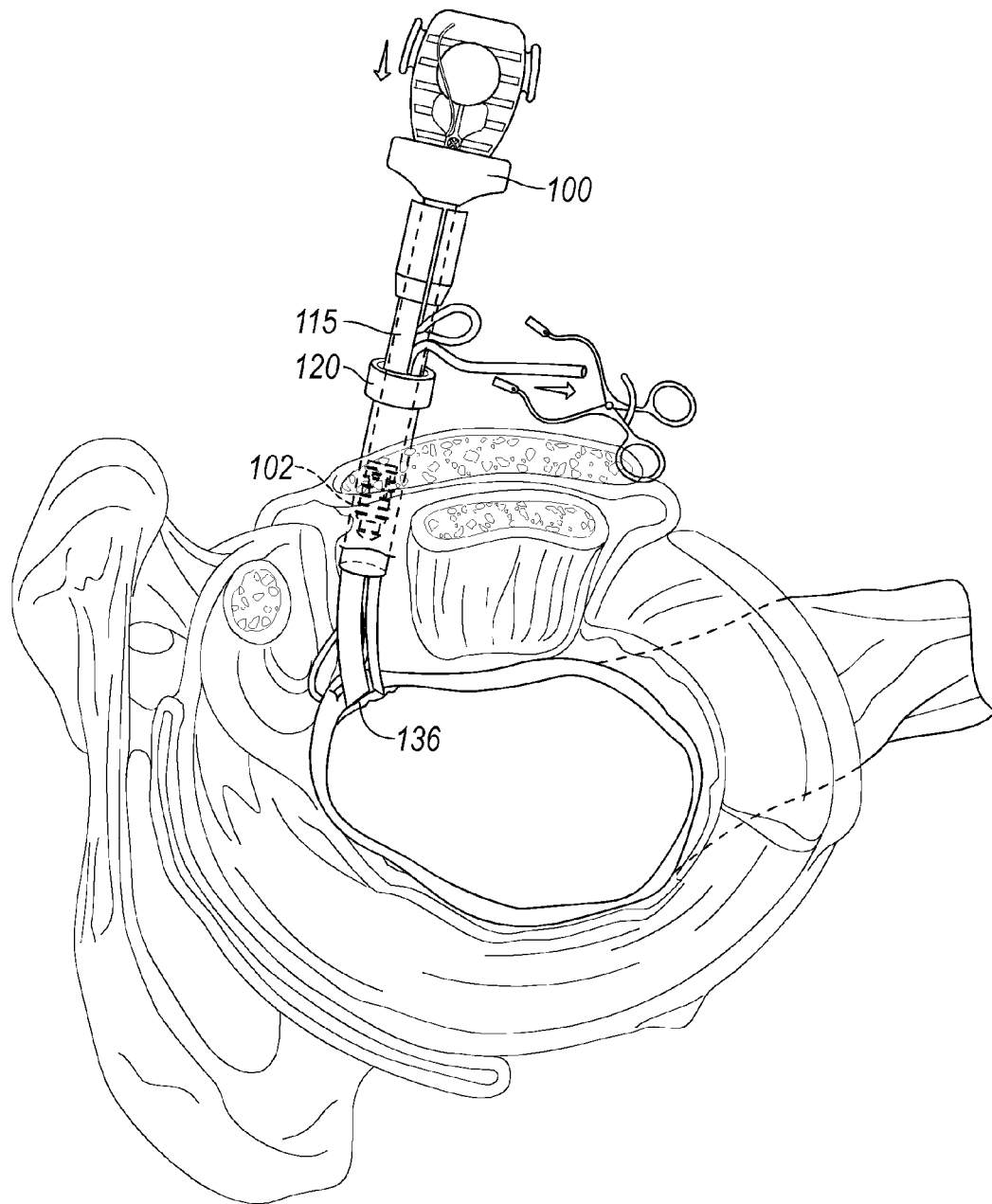


FIG. 27

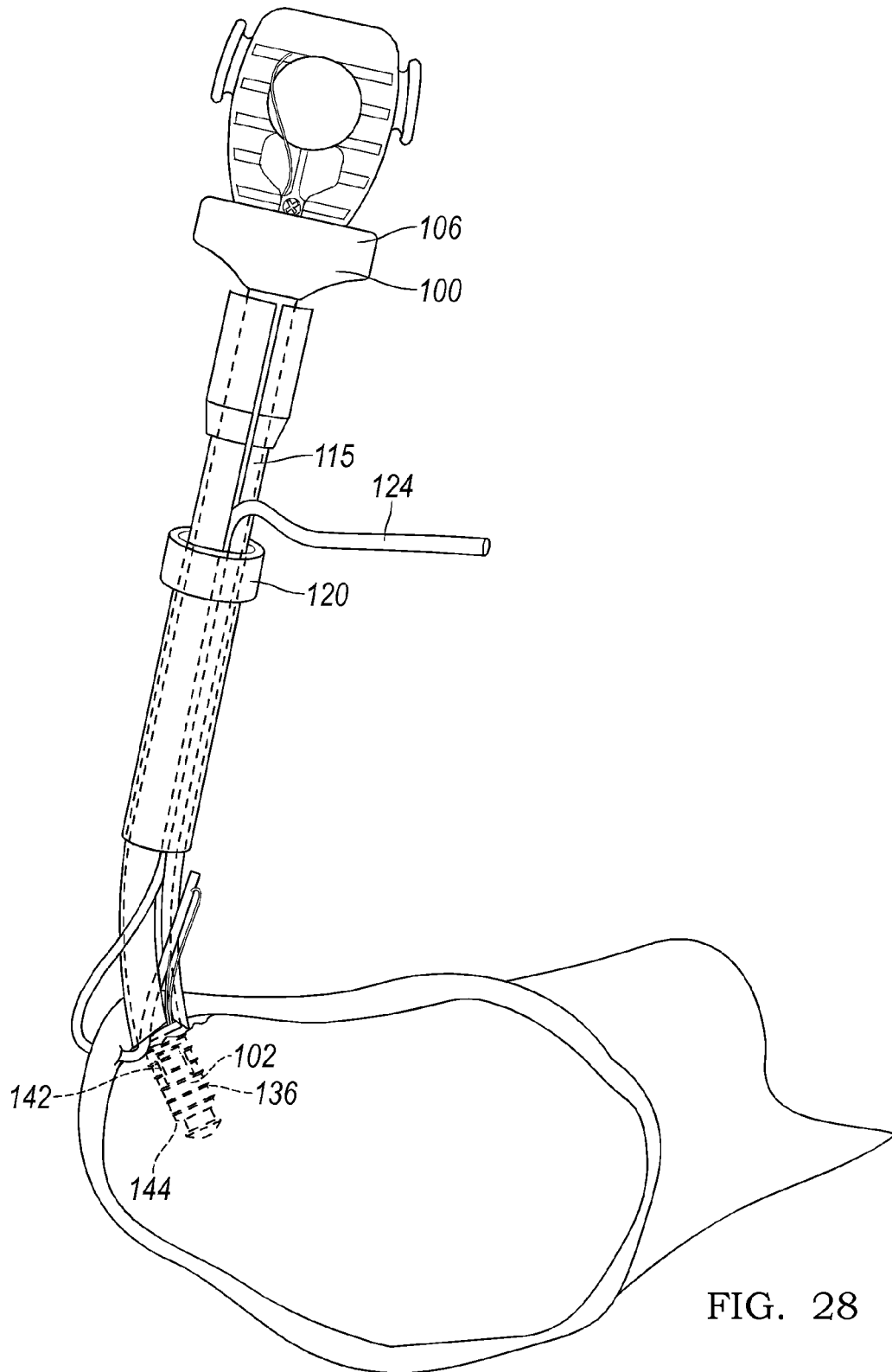


FIG. 28

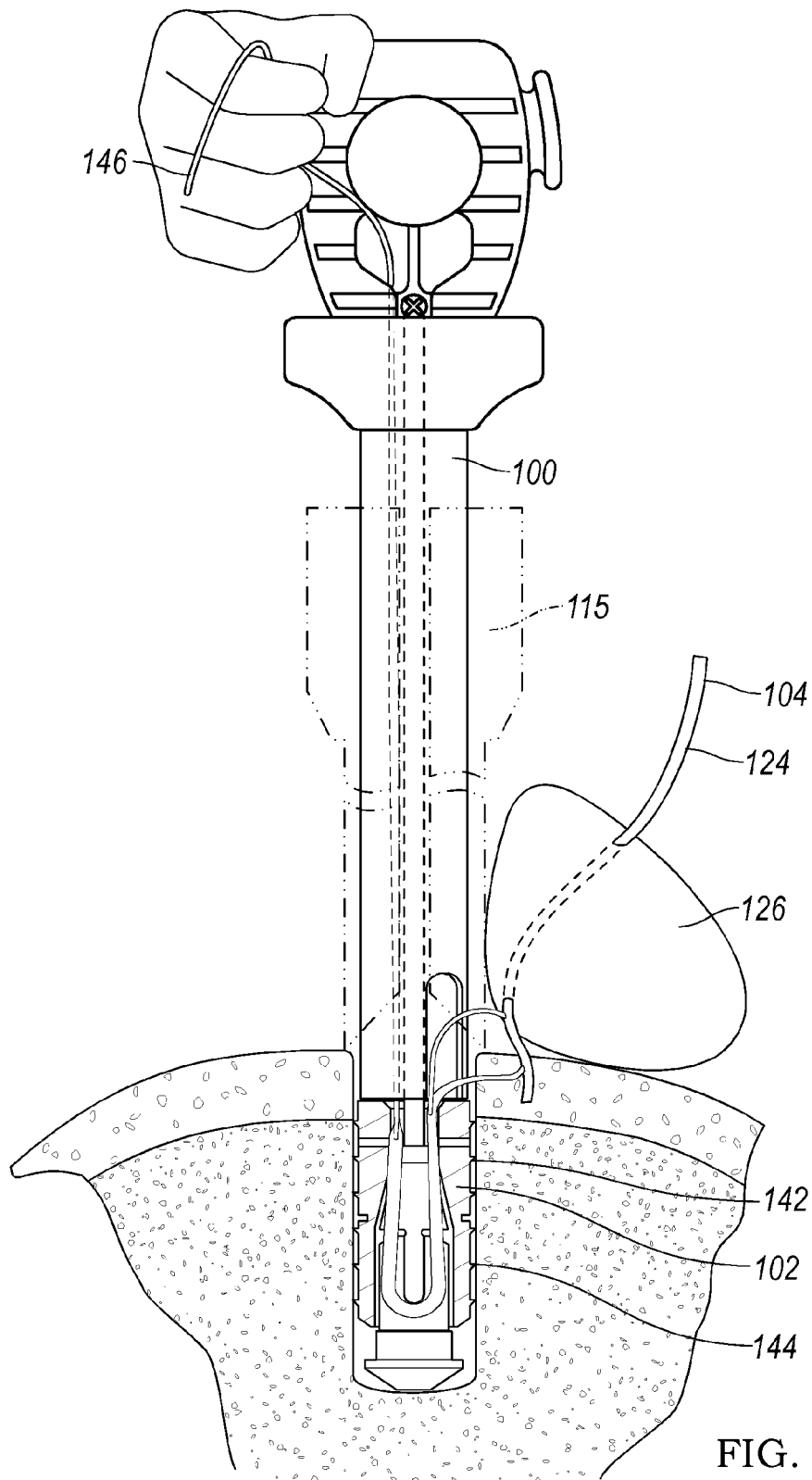


FIG. 29

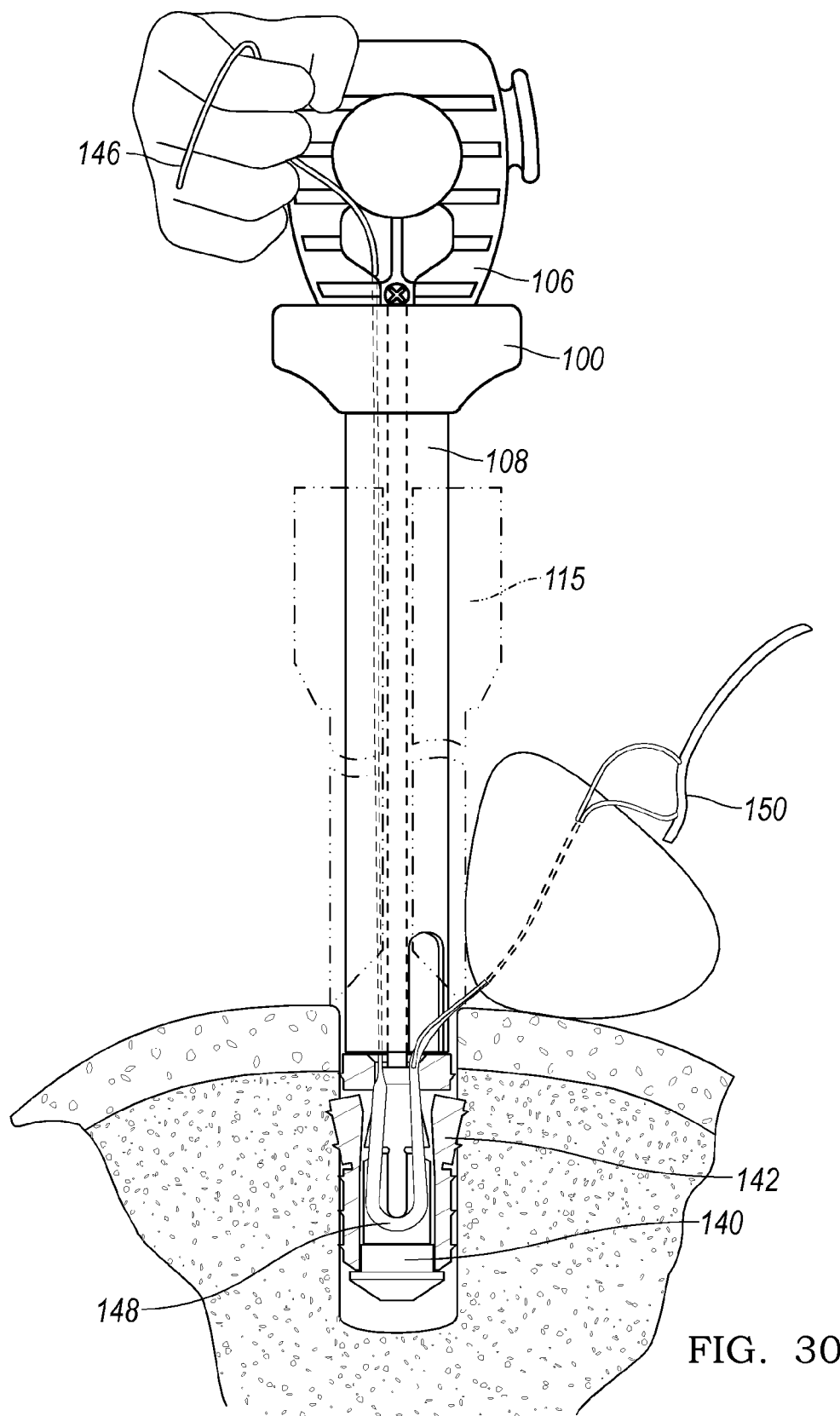


FIG. 30

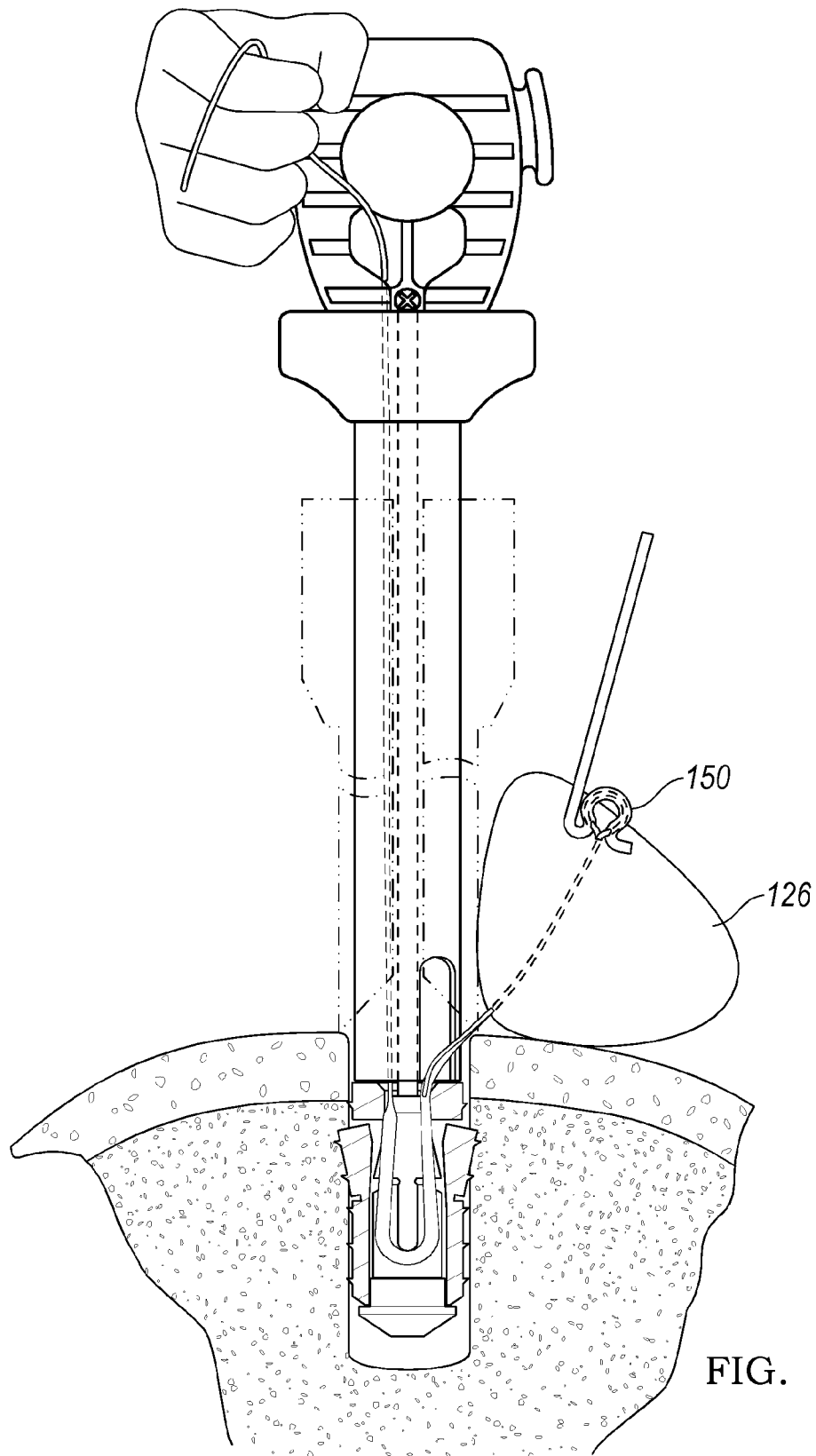


FIG. 31

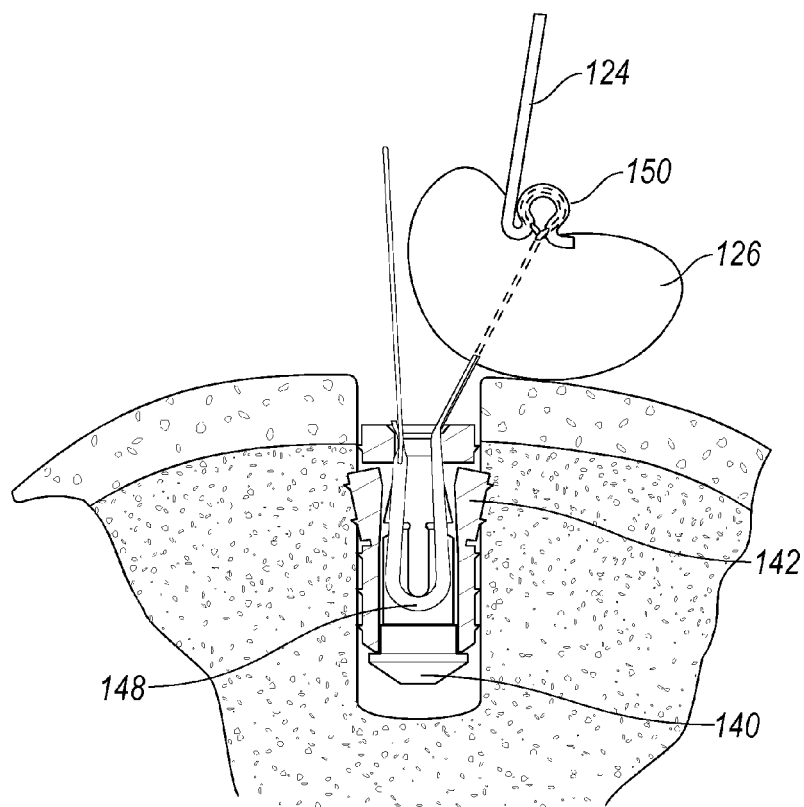


FIG. 32

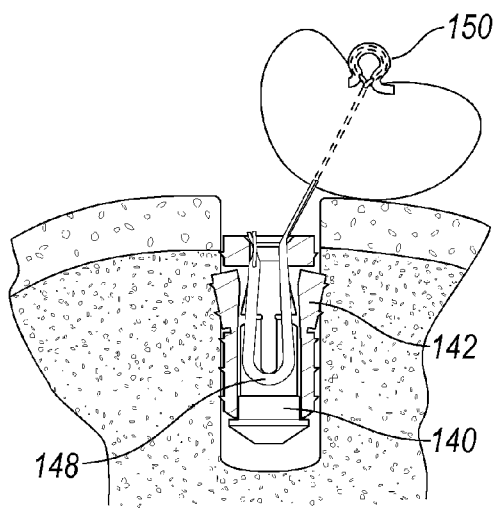


FIG. 33A

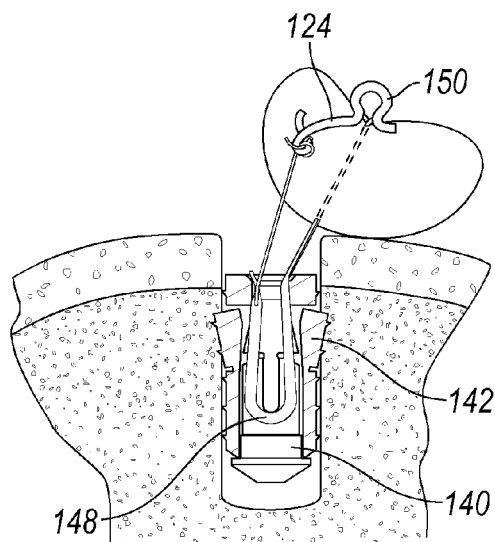


FIG. 33B

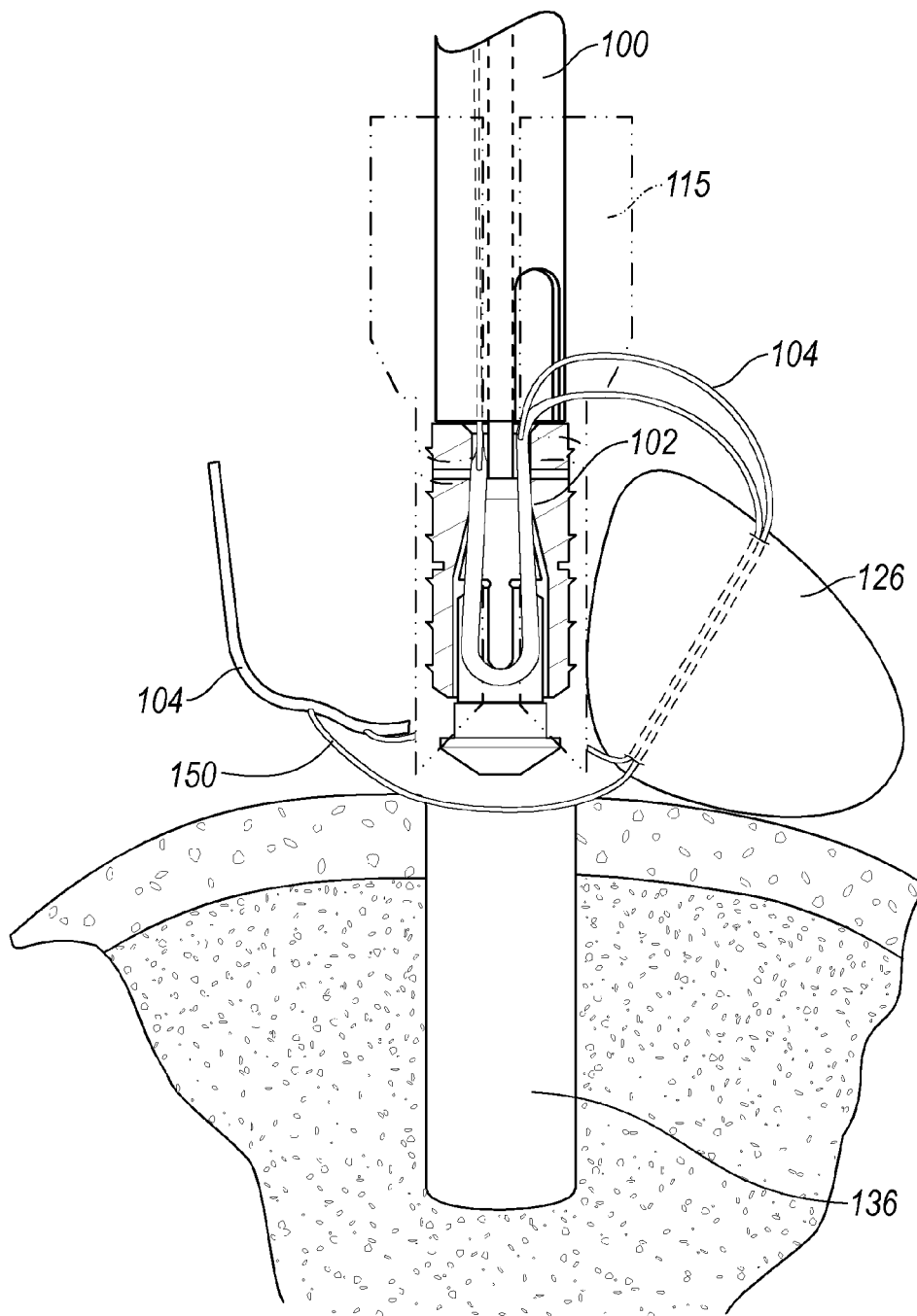


FIG. 34

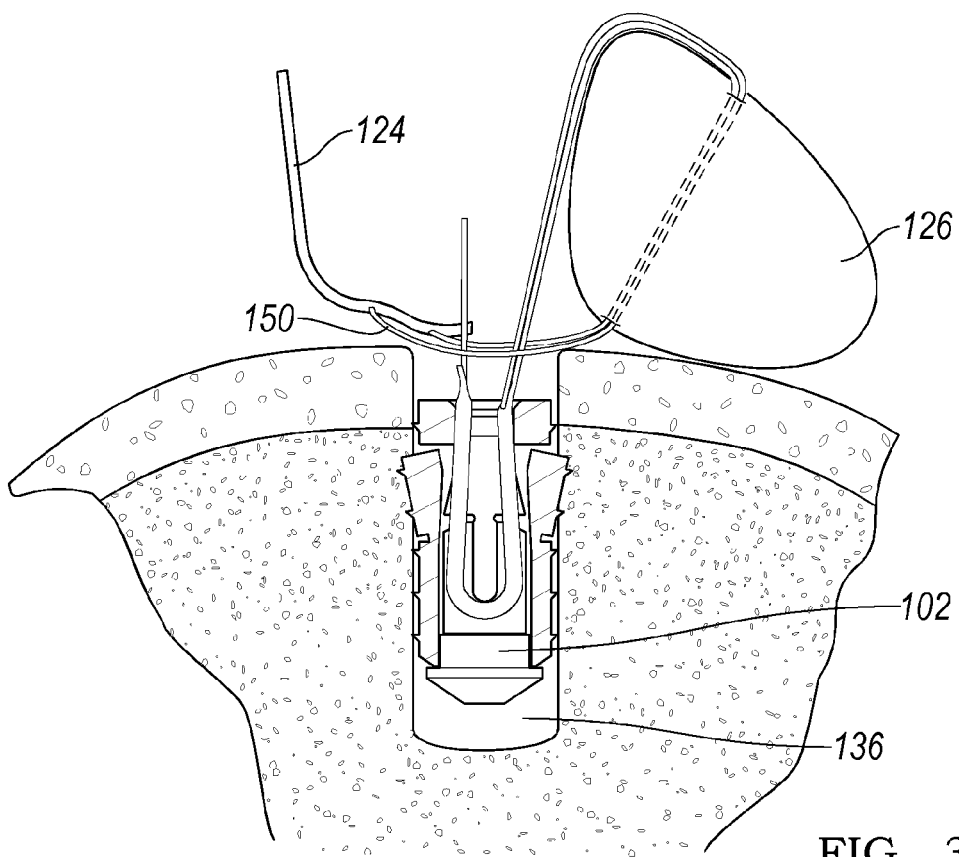


FIG. 35

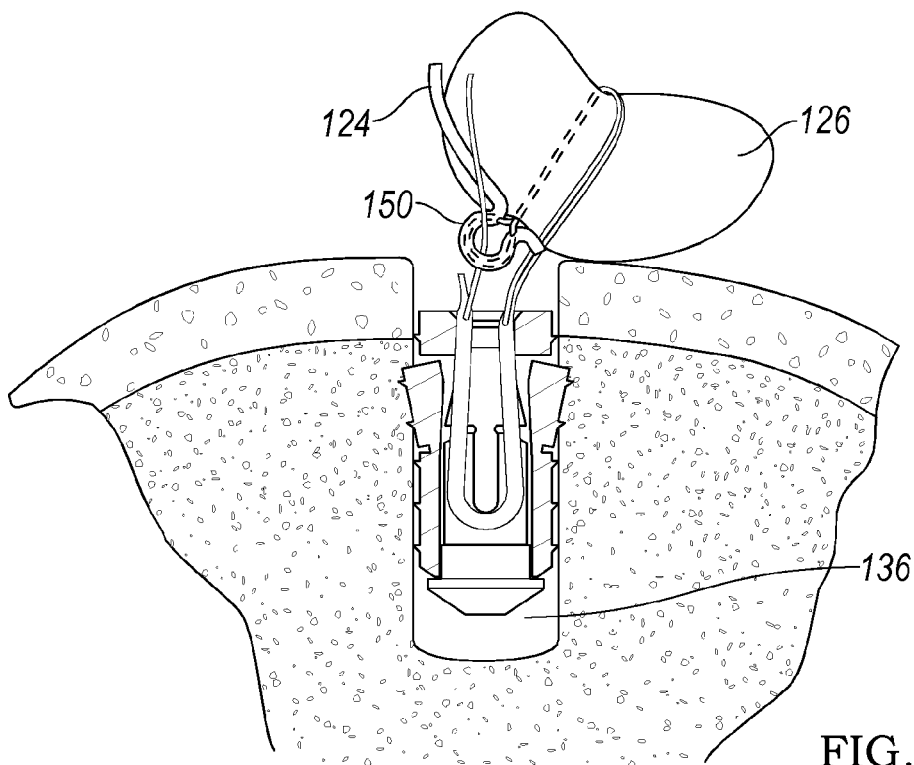
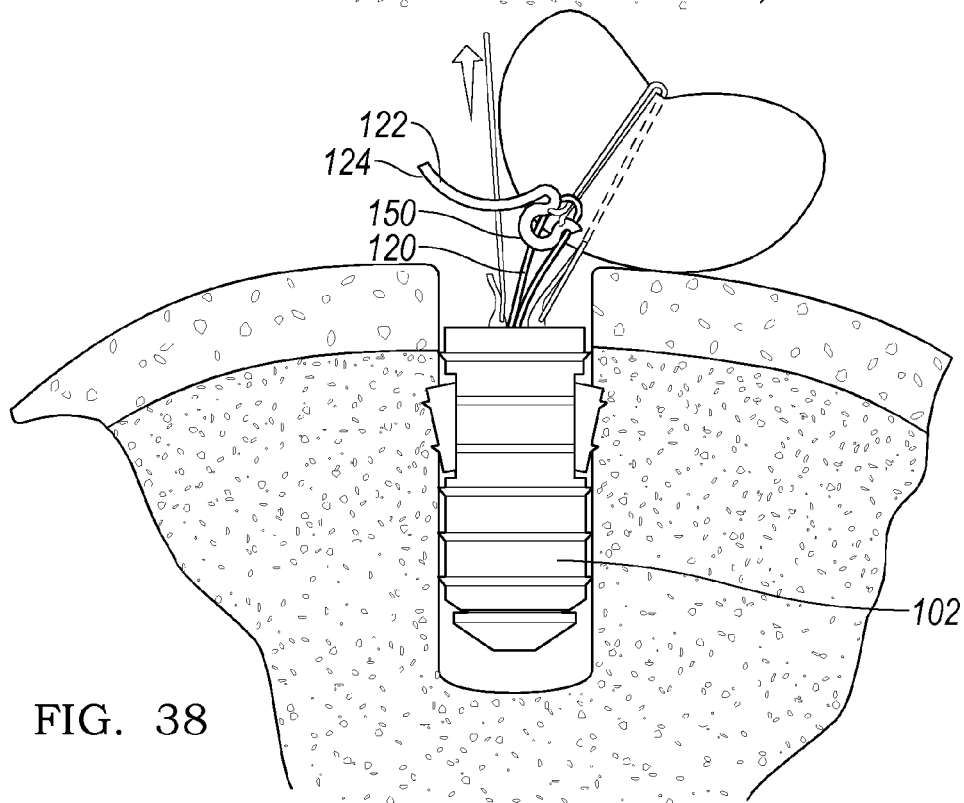
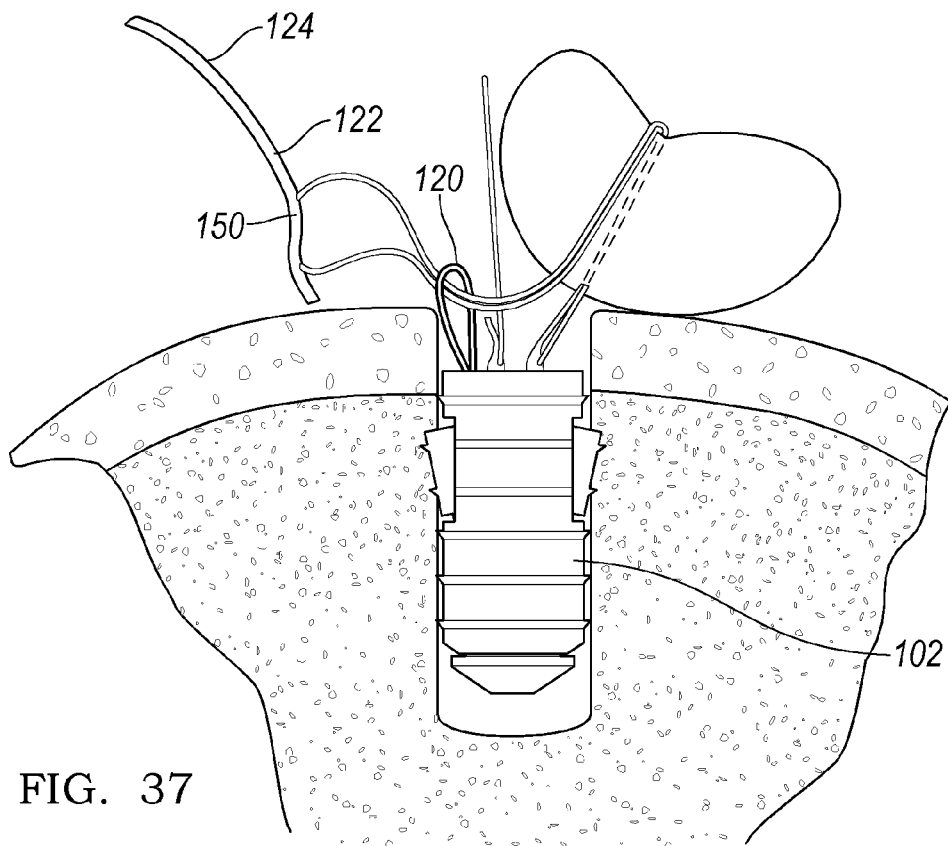
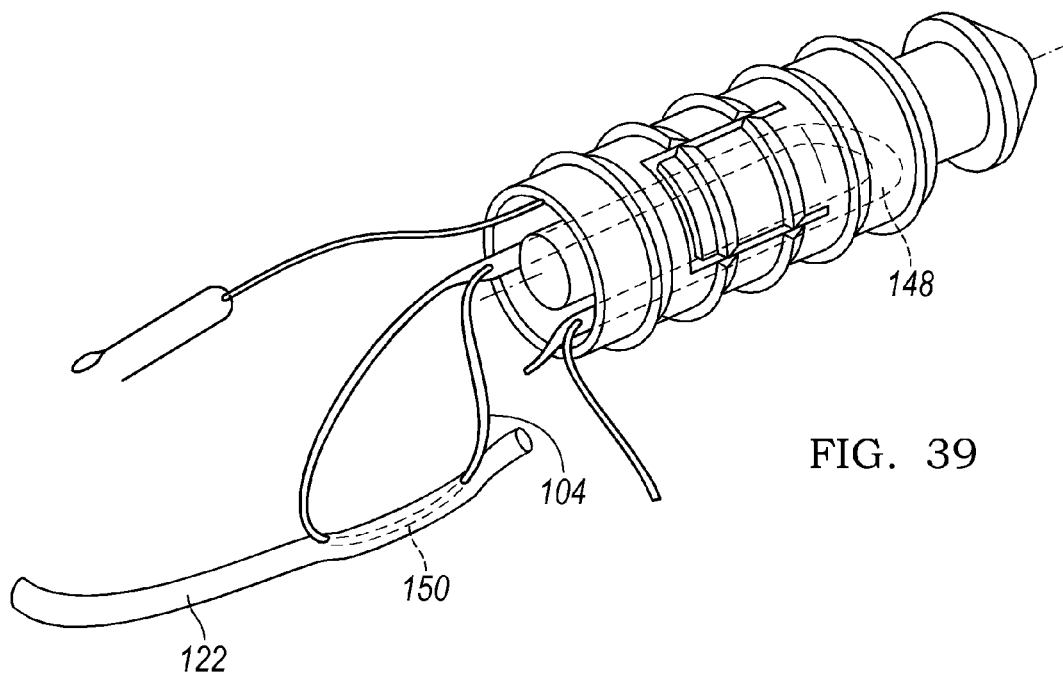
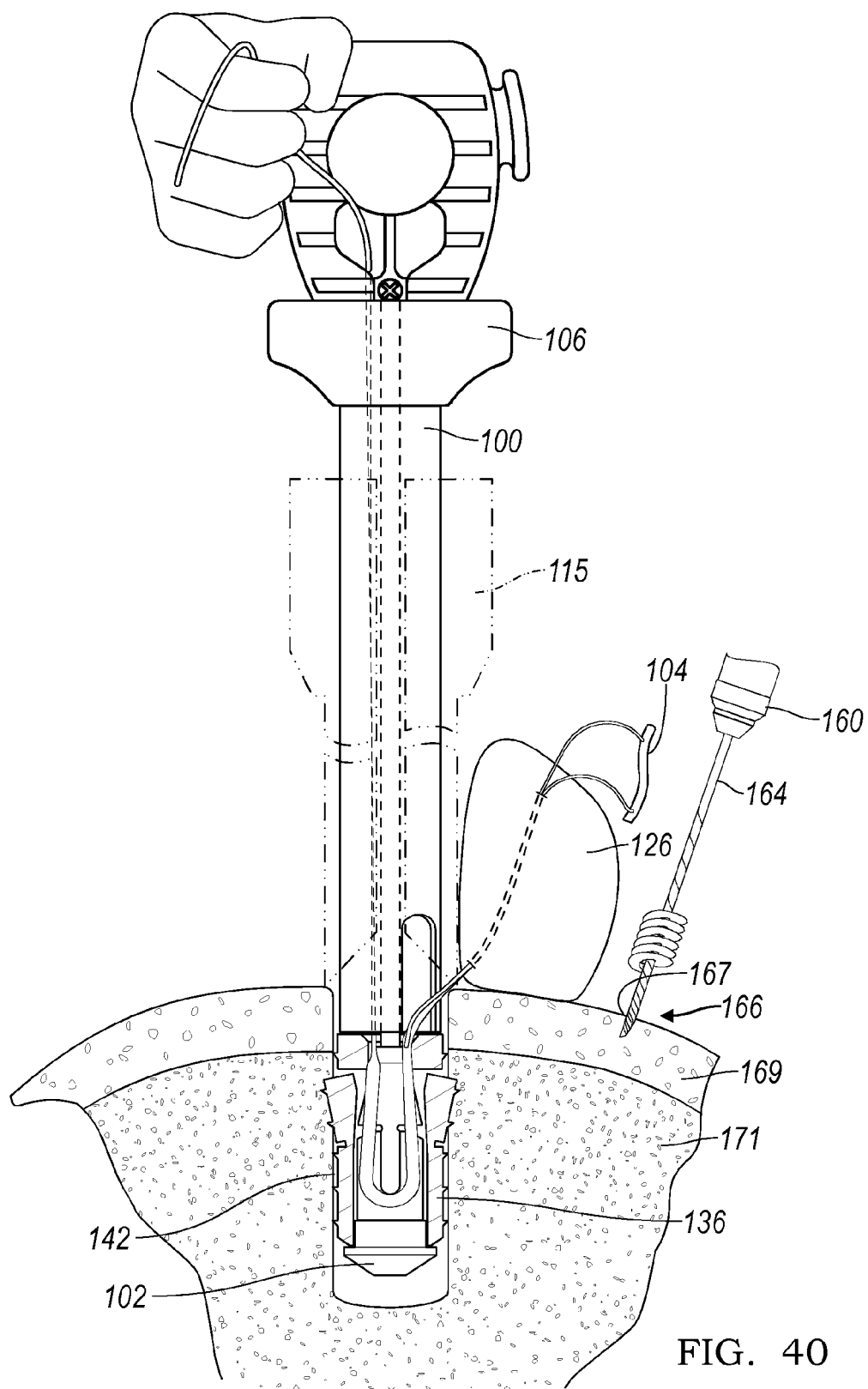
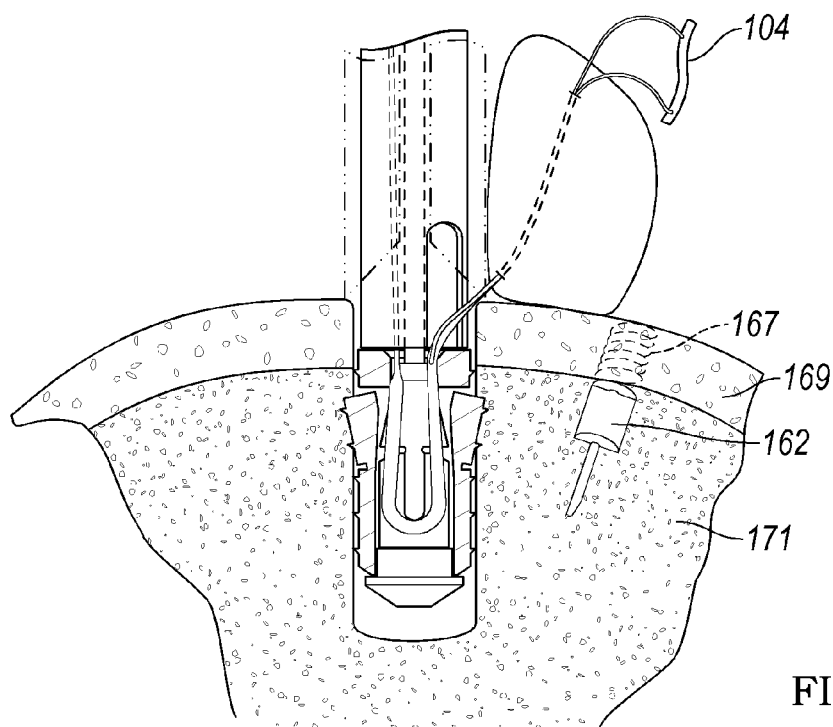
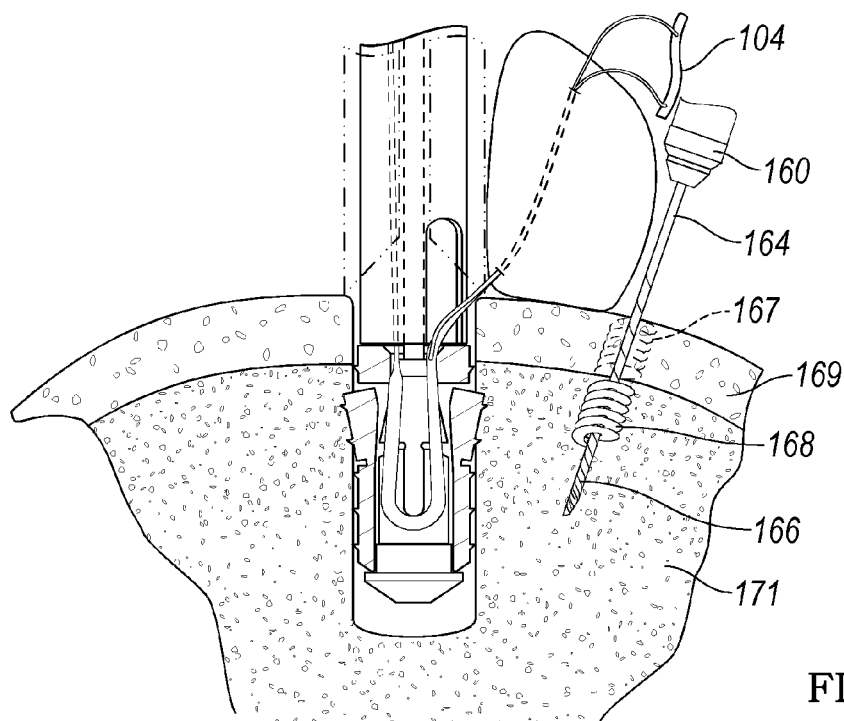


FIG. 36









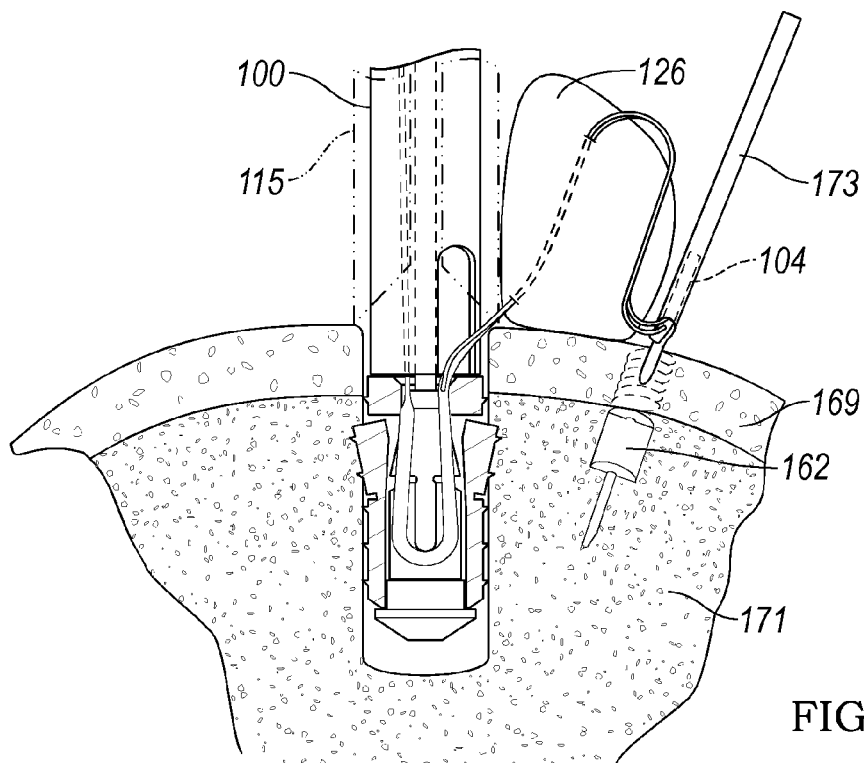


FIG. 43

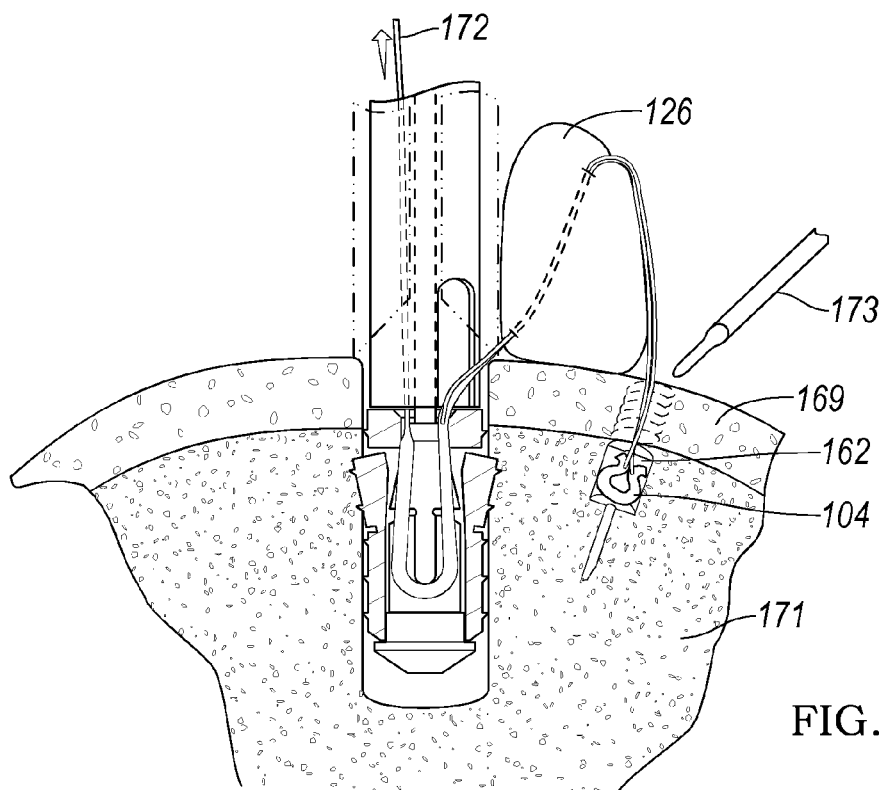


FIG. 44

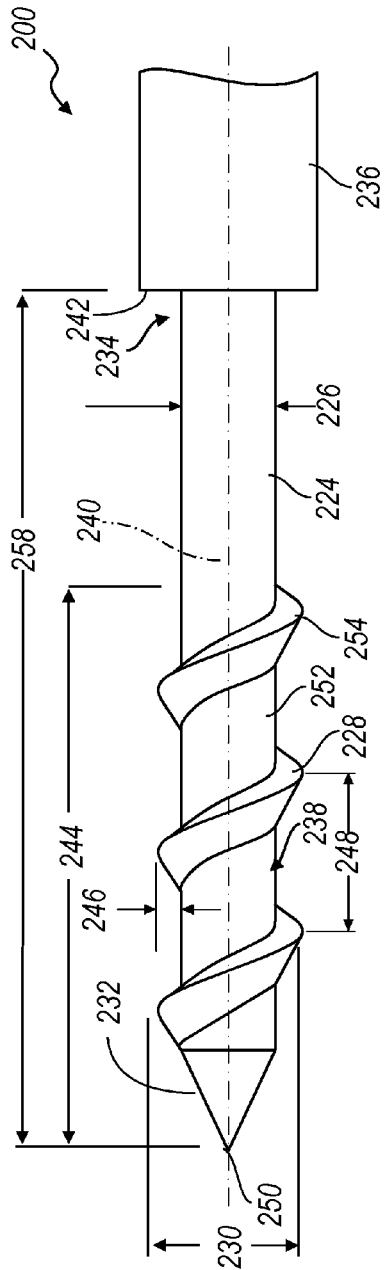


FIG. 45

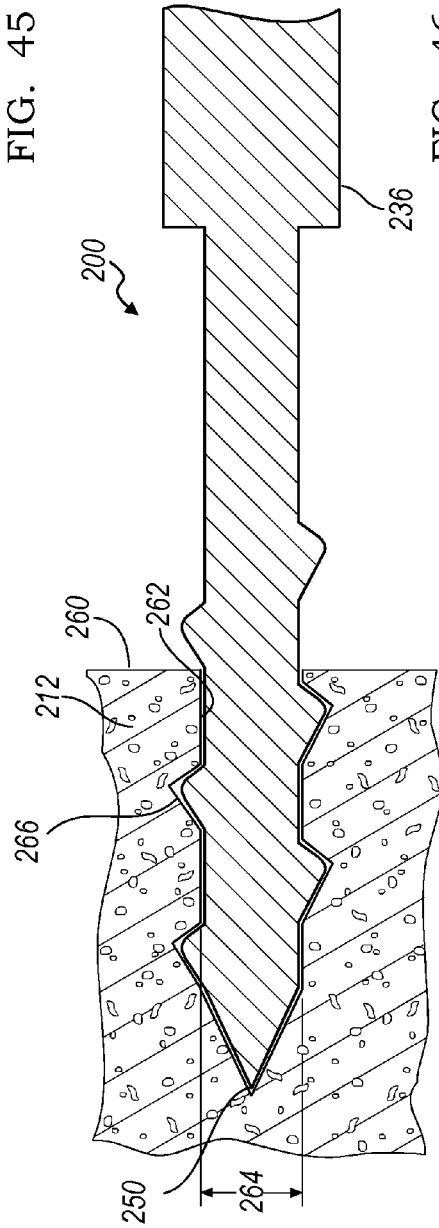


FIG. 46

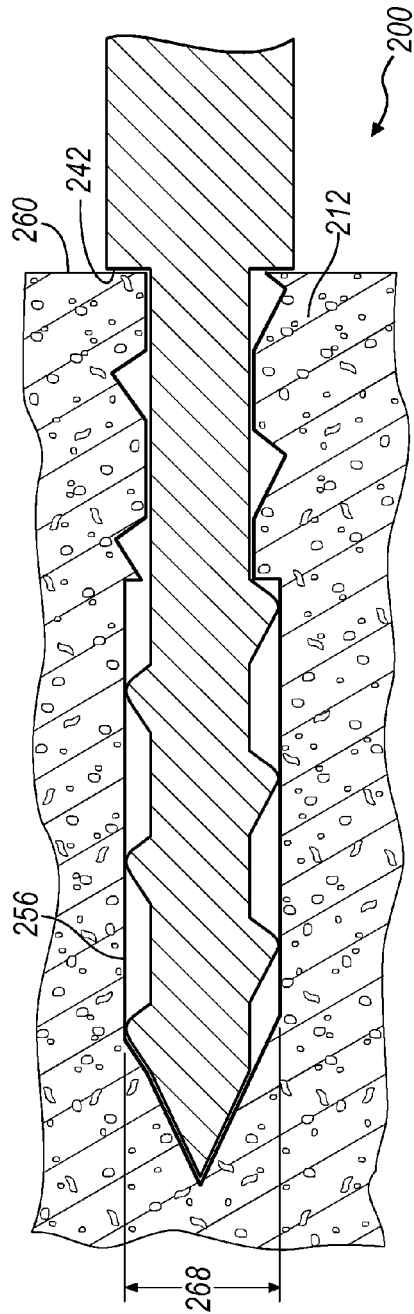


FIG. 47

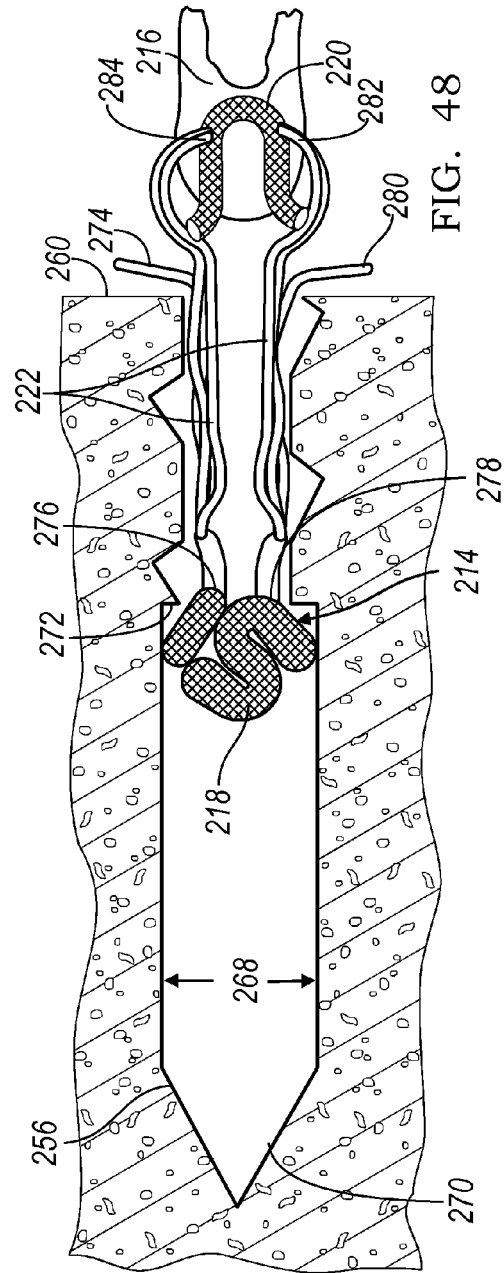


FIG. 48

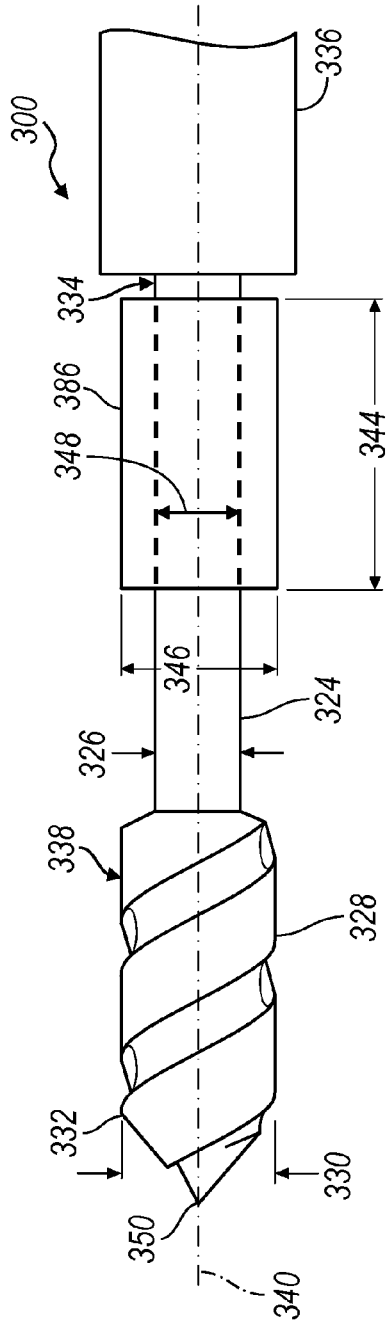


FIG. 49

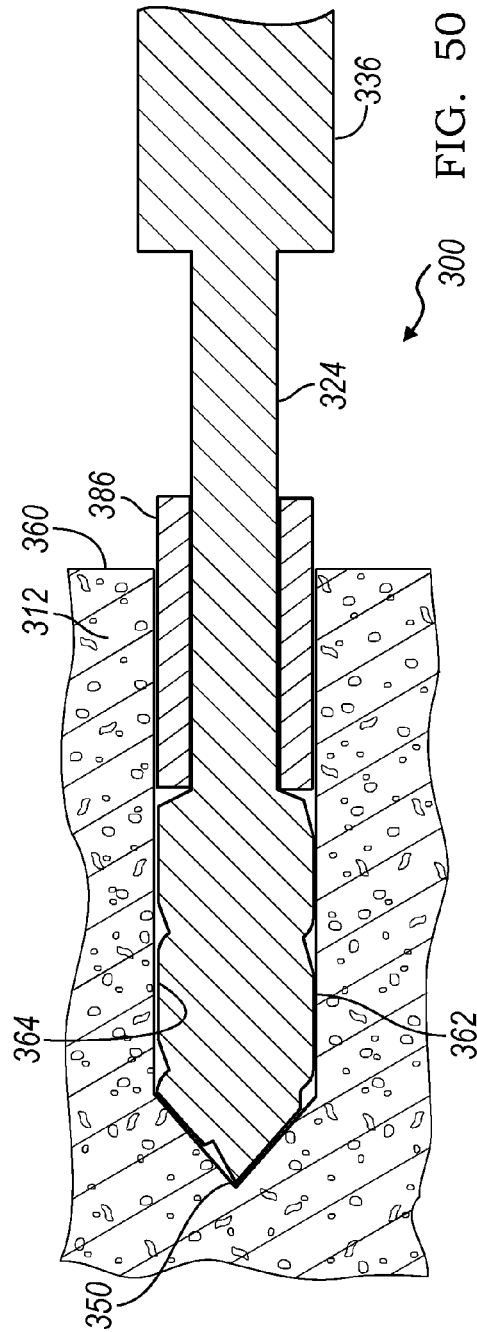


FIG. 50

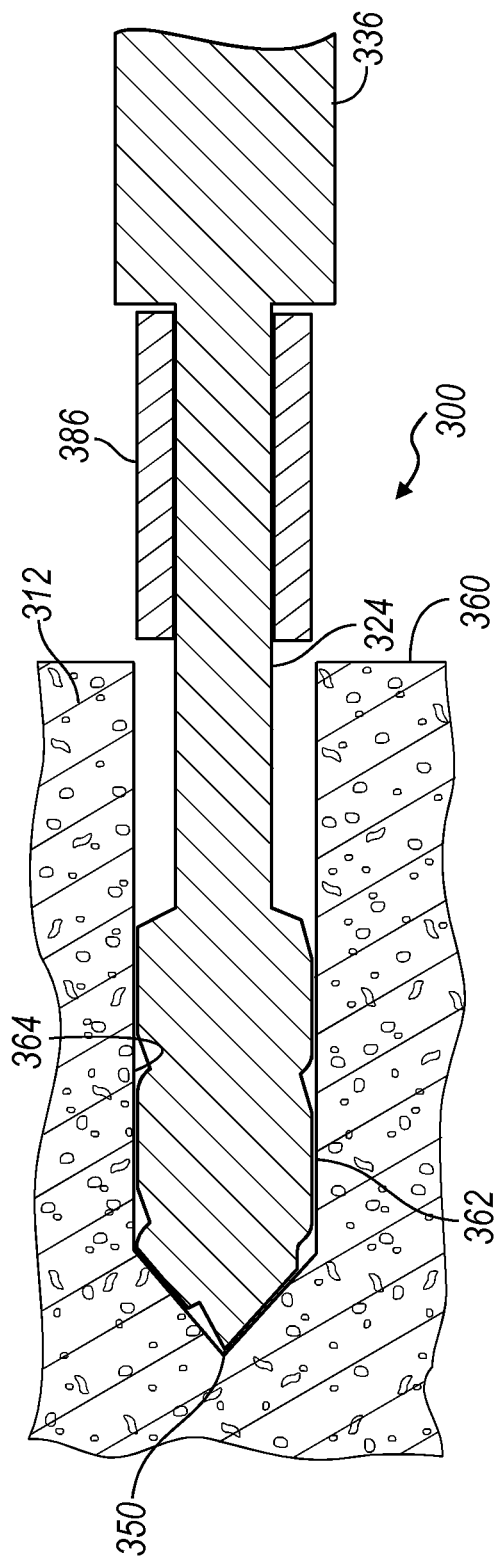


FIG. 51

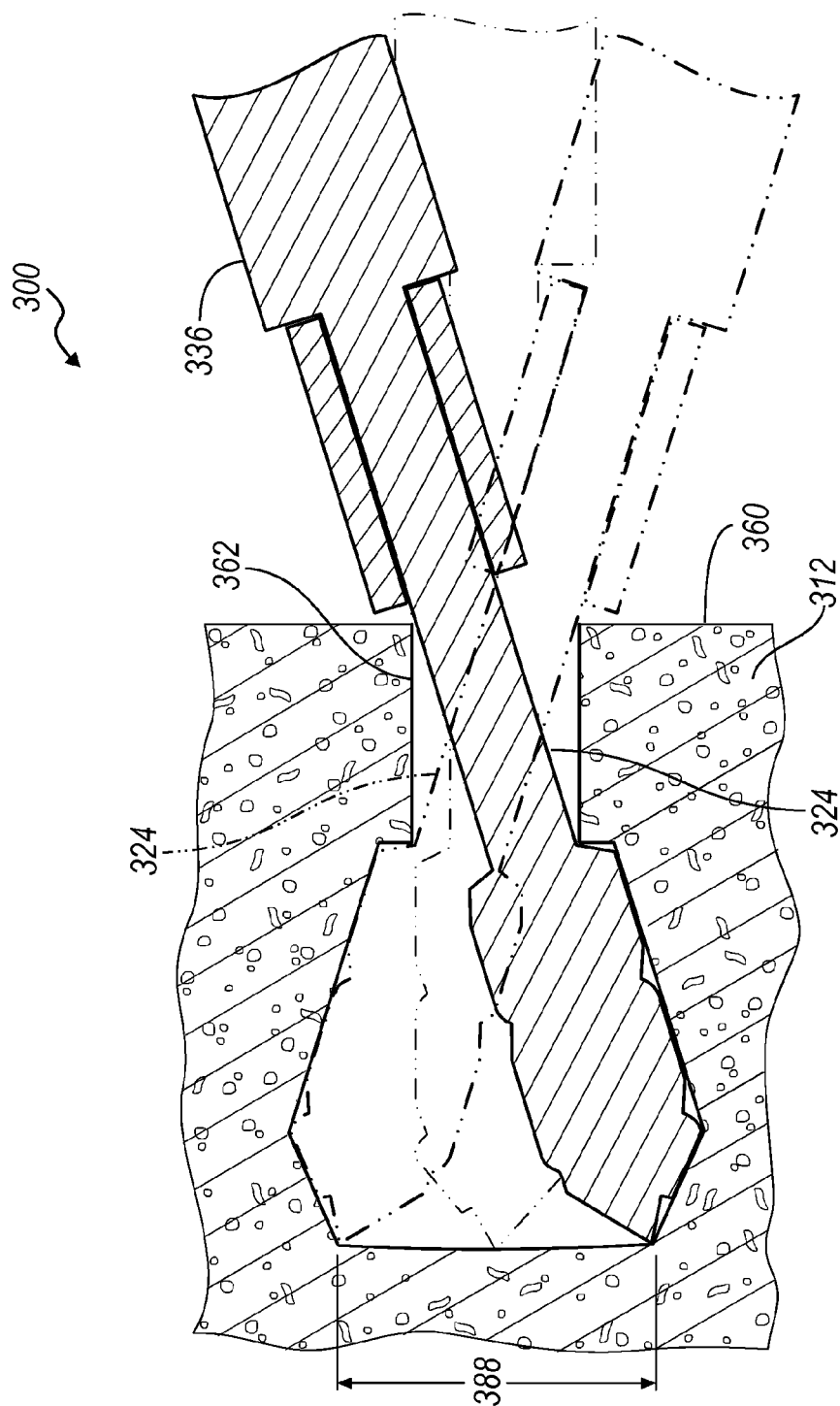


FIG. 52A

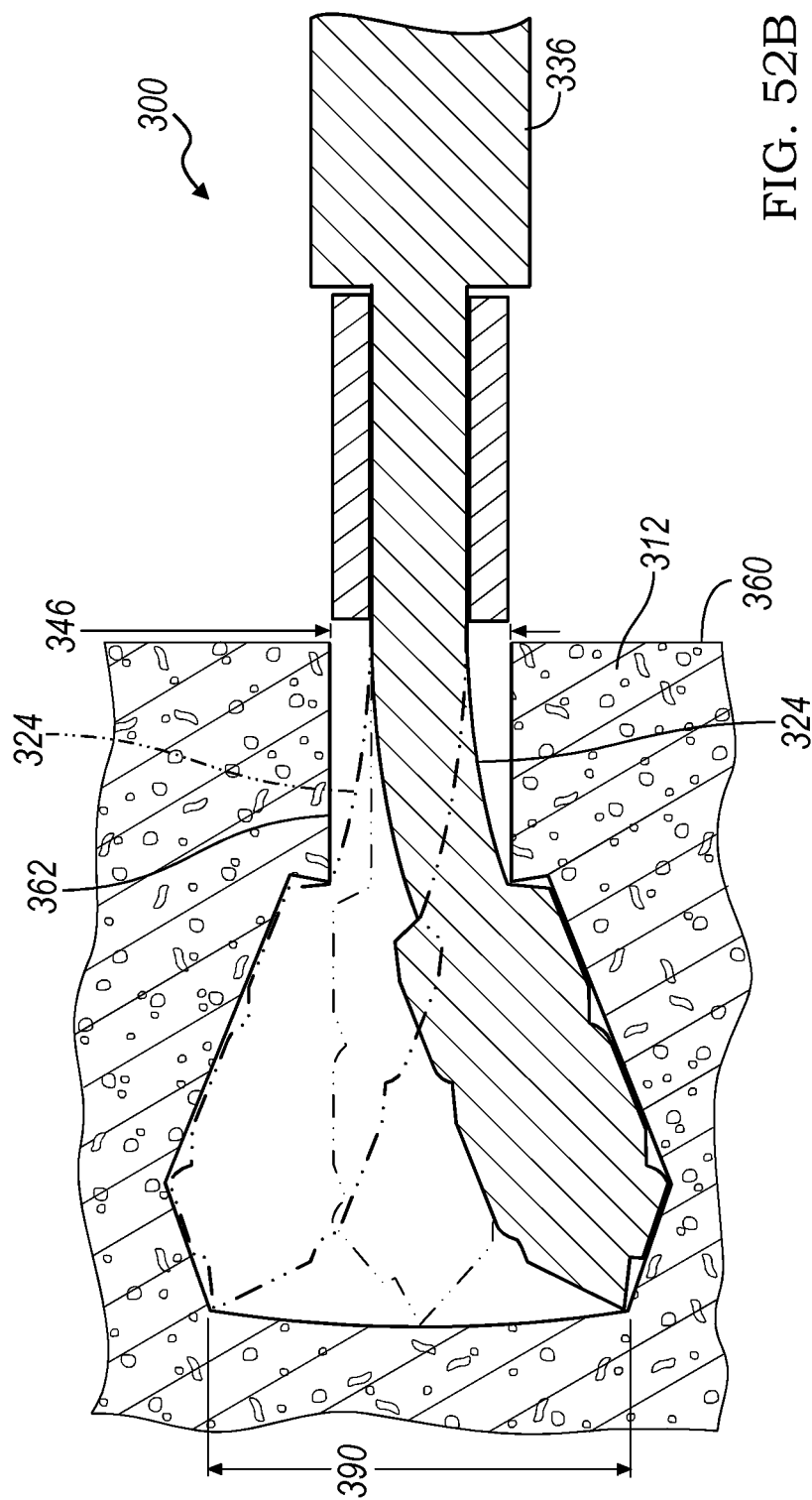


FIG. 52B

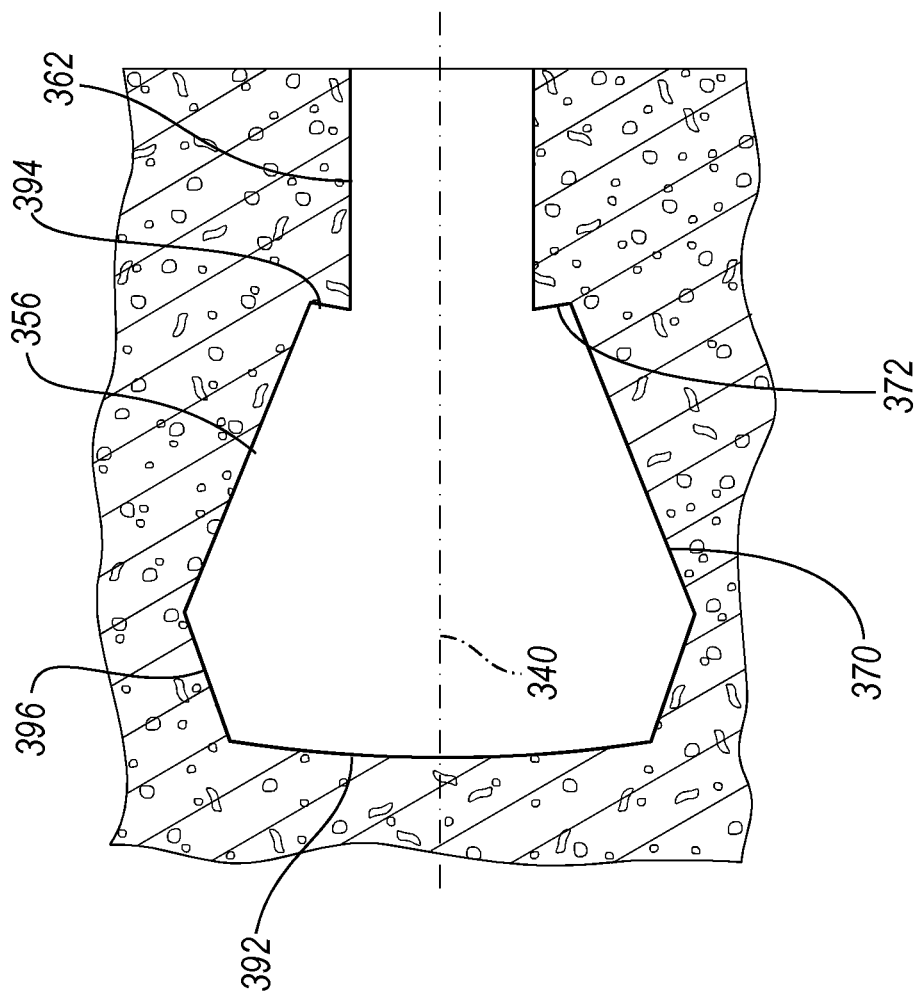


FIG. 53

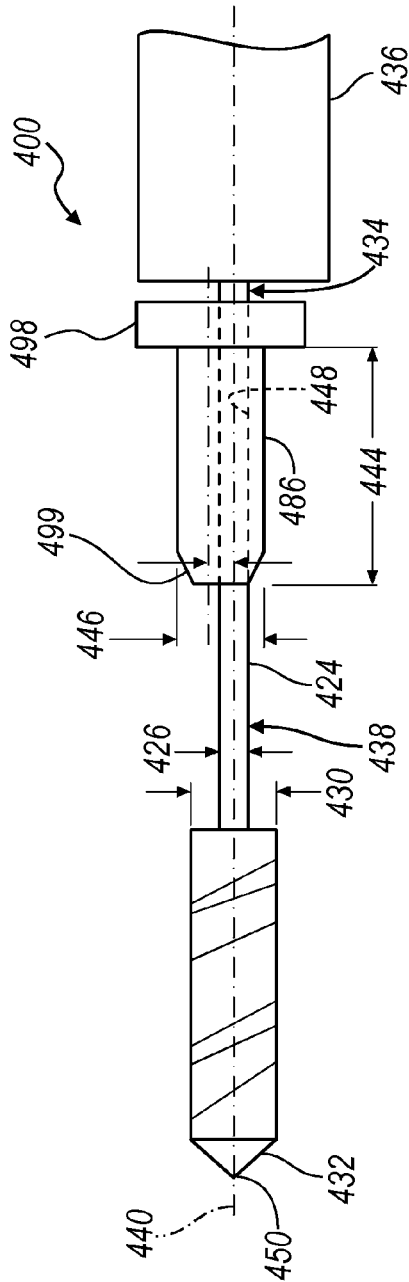


FIG. 54

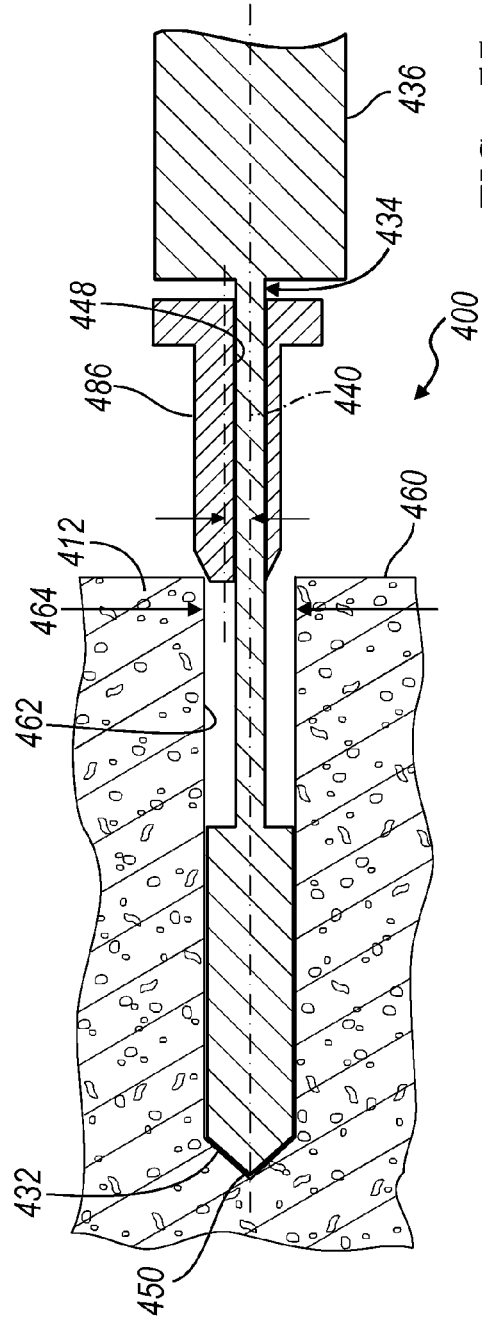


FIG. 55

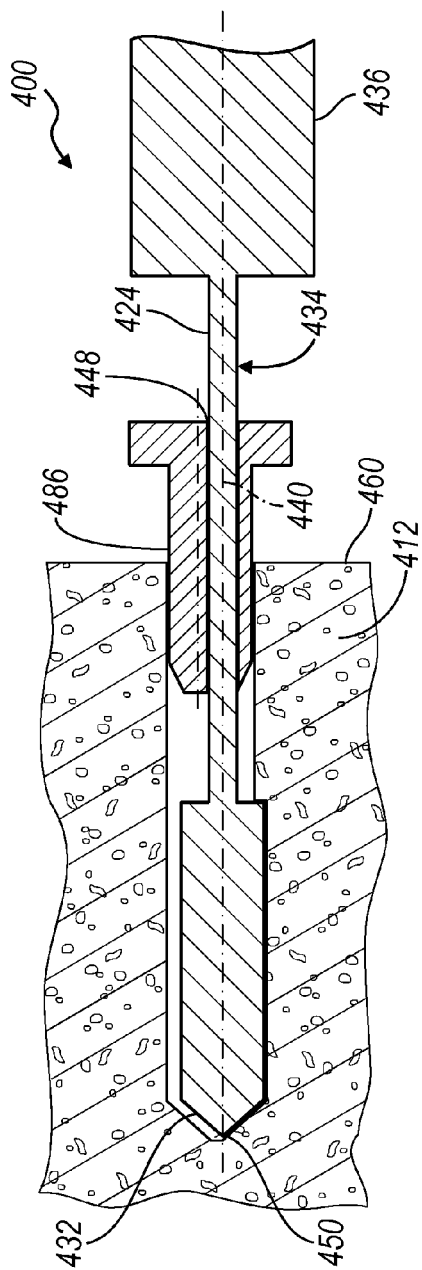


FIG. 56

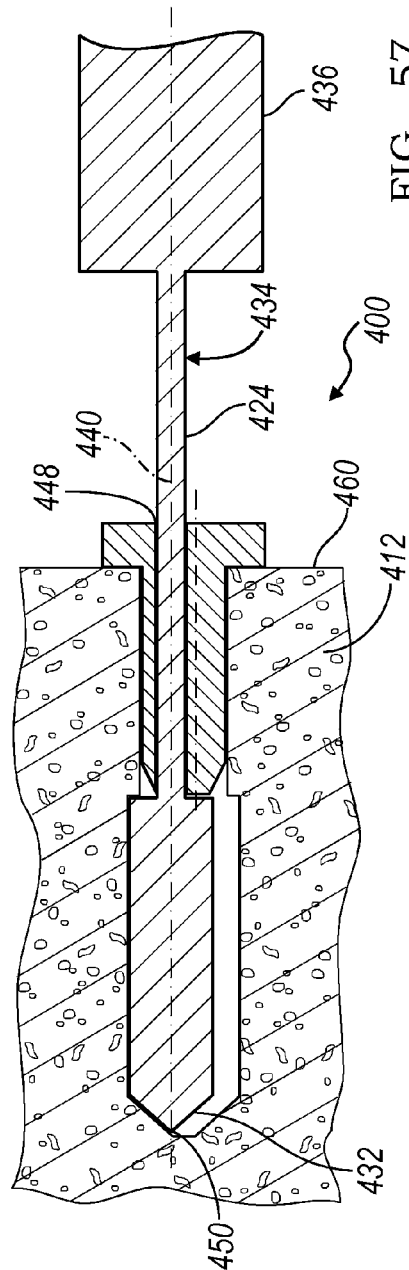


FIG. 57

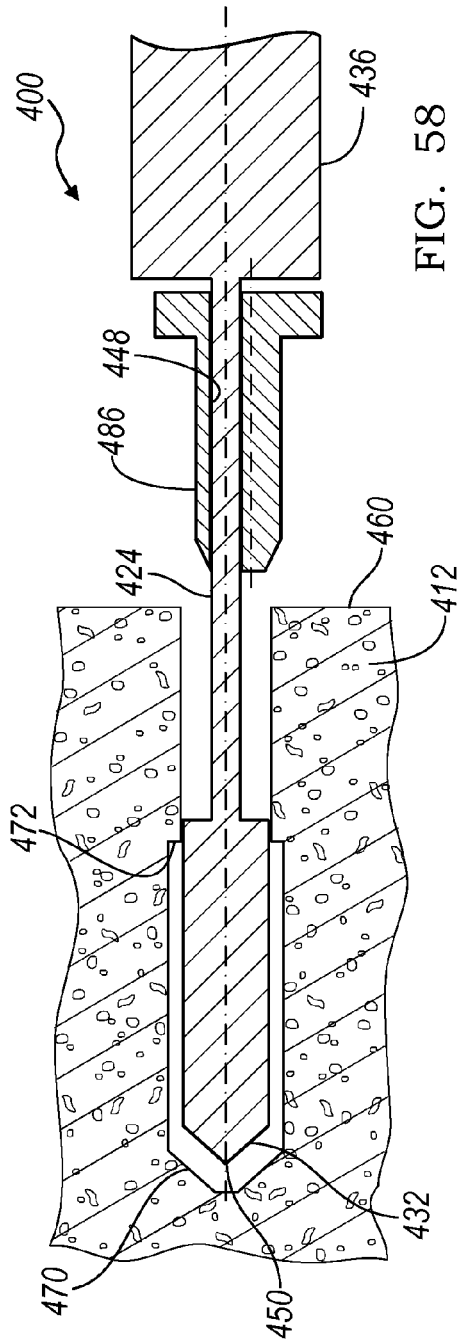


FIG. 58

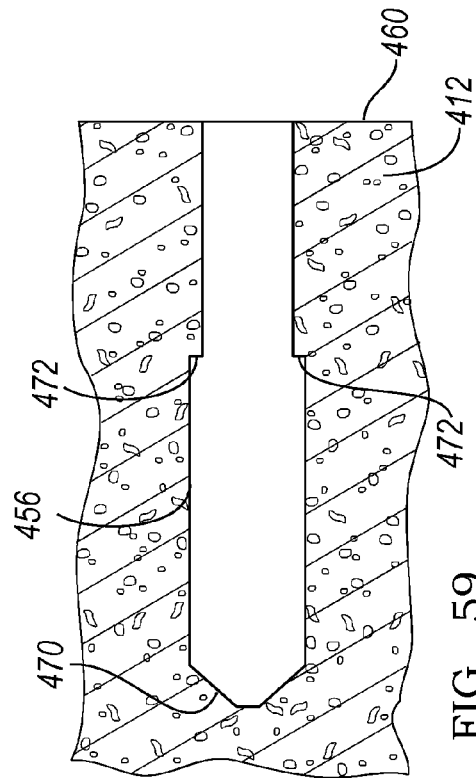


FIG. 59

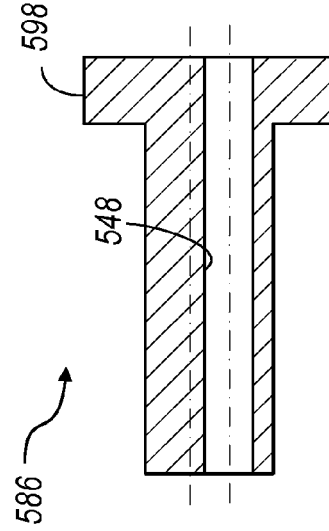


FIG. 60

1

METHOD AND APPARATUS FOR COUPLING SOFT TISSUE TO A BONE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part application of U.S. patent application Ser. No. 12/474,802, filed on May 29, 2009, now U.S. Pat. No. 8,088,130 which is a continuation-in-part of (1.) U.S. patent application Ser. No. 11/541,506 filed on Sep. 29, 2006, now U.S. Pat. No. 7,601,165 issued on Oct. 13, 2009; (2.) U.S. patent application Ser. No. 11/541,505 filed on Sep. 29, 2006, now U.S. Pat. No. 7,658,751 issued on Feb. 9, 2010; (3.) U.S. patent application Ser. No. 12/014,399 filed on Jan. 15, 2008, now U.S. Pat. No. 7,909,851 issued on Mar. 22, 2011; (4.) U.S. patent application Ser. No. 12/014,340 filed on Jan. 15, 2008, now U.S. Pat. No. 7,905,904 issued on Mar. 15, 2011; (5.) U.S. patent application Ser. No. 11/935,681 filed on Nov. 6, 2007, now U.S. Pat. No. 7,905,903 issued on Mar. 15, 2011; (6.) U.S. patent application Ser. No. 11/869,440 filed on Oct. 9, 2007, now U.S. Pat. No. 7,857,830 issued on Dec. 28, 2010; (7.) U.S. patent application Ser. No. 11/784,821 filed on Apr. 10, 2007; (8.) U.S. patent application Ser. No. 11/347,661 filed on Feb. 3, 2006, now U.S. Pat. No. 7,749,250 issued on Jul. 6, 2010; and (9.) U.S. patent application Ser. No. 11/347,662 filed on Feb. 3, 2006, now abandoned.

This application is also a continuation-in-part of (1.) U.S. patent application Ser. No. 12/196,405 filed on Aug. 22, 2008 now U.S. Pat. No. 8,128,658; (2.) U.S. patent application Ser. No. 12/196,407, filed on Aug. 22, 2008 now U.S. Pat. No. 8,137,382; (3.) U.S. patent application Ser. No. 12/196,410, filed on Aug. 22, 2008 now U.S. Pat. No. 8,118,836; and (4.) U.S. patent application Ser. No. 13/071,563, filed on Mar. 25, 2011. The disclosures of the above applications are incorporated herein by reference.

FIELD

The present disclosure relates to method of coupling soft tissue and, more particularly, to a method of coupling soft tissue to a bone.

BACKGROUND

The statements in this section merely provide background information related to the present disclosure and may not constitute prior art.

It is commonplace in arthroscopic procedures to employ sutures and anchors to secure soft tissues to bone. Despite their widespread use, several improvements in the use of sutures and suture anchors may be made. For example, the procedure of tying knots may be very time consuming, thereby increasing the cost of the procedure and limiting the capacity of the surgeon. Furthermore, the strength of the repair may be limited by the strength of the knot. This latter drawback may be of particular significance if the knot is tied improperly as the strength of the knot in such situations may be significantly lower than the tensile strength of the suture material.

To improve on these uses, sutures having a single pre-formed loop have been provided. FIG. 1 represents a prior art suture construction. As shown, one end of the suture is passed through a passage defined in the suture itself. The application of tension to the ends of the suture pulls a portion of the suture through the passage, causing a loop formed in the suture to

2

close. Relaxation of the system, however may allow a portion of the suture to translate back through the passage, thus relieving the desired tension.

It is an object of the present teachings to provide an alternative device for anchoring sutures to bone and soft tissue. The device, which is relatively simple in design and structure, is highly effective for its intended purpose.

SUMMARY

To overcome the aforementioned deficiencies, a method for attaching a fixation device to a bone is disclosed. The method includes bringing a bone cutting tool that extends along a longitudinal axis into engagement with an outer surface of the bone. The bone cutting tool is then rotated about the longitudinal axis while driving the bone cutting tool from the outer surface of the bone to a predetermined depth in the bone to form a bore. The bone cutting tool is continuously rotated at the predetermined depth to establish an enlarged bone pocket at a distal end of the bore. The bone pocket defines a shoulder extending around a circumference between the bone pocket and the bore. The bone cutting tool is next removed from the bone pocket and the bore and the fixation device is inserted into the bone pocket through the bore. The fixation device is now positioned against the shoulder of the bone pocket.

A method of attaching a fixation device to a bone is also disclosed. A bone cutting tool having a helical flute is brought into engagement with an outer surface of the bone. The bone cutting tool is rotated about a longitudinal axis to form a first bore having a helical flute groove extending from the outer surface of the bone to a depth within the bone. The bone cutting tool is continuously rotated at the depth to establish a second bore having a shoulder and a continuous sidewall. The shoulder extends around a circumference between the second bore and the first bore. The bone cutting tool is aligned with the first bore. The bone cutting tool is drawn out of the second and first bores. The fixation device is inserted into the second bore through the first bore. The fixation device is then positioned against the shoulder of the second bore.

In another embodiment, a method of attaching a fixation device to a bone is disclosed. A bone cutting tool is rotated through a cortical bone about a longitudinal axis of the tool to a predetermined depth in the cancellous bone to form a bore. The bone cutting tool includes a body portion, a first member, and a second member. The body portion extends from a proximal end to a distal end along the longitudinal axis. The first member extends radially outwardly from the distal end of the body portion. The first member has a first diameter defined by at least one transverse cutting flute. The second member extends radially outwardly from the body portion proximal the first member and has a second diameter greater than the first diameter. The bone cutting tool is continuously rotated at the predetermined depth to establish an enlarged bone pocket at a distal end of the bore. The bone pocket defines a shoulder extending around a circumference between the bone pocket and the bore.

Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

3

FIG. 1 represents a prior art suture configuration;
FIGS. 2A and 2B represent suture constructions according to the teachings;

FIG. 3 represents the formation of the suture configuration shown in FIG. 2A;

FIGS. 4A and 4B represent alternate suture configurations;
FIGS. 5-7 represent further alternate suture configurations;
FIG. 8 represents the suture construction according to FIG. 5 coupled to a bone engaging fastener;

FIGS. 9-11 represent the coupling of the suture construction according to FIG. 5 to a bone screw;

FIGS. 12A-12E represent the coupling of a soft tissue to an ACL replacement in a femoral/humeral reconstruction;

FIGS. 13A-13D represent a close-up view of the suture shown in FIGS. 1-11C;

FIGS. 14A and 14B represent the coupling of the suture construction of FIG. 2A and FIG. 4 to bone;

FIGS. 15A-15G represent the coupling of soft tissue to a bone according to the present teachings;

FIGS. 16A-16D represent the coupling of soft tissue to a bone using alternate teachings;

FIGS. 17A-17E represent the coupling of soft tissue to a bone using alternate teachings;

FIGS. 18A-18C represent the coupling of soft tissue to a bone using multiple collapsible loop structures;

FIGS. 19A-19C represent the coupling of soft tissue to a bone using yet alternate teachings;

FIGS. 20A and 20B represent a meniscal repair according to the present teachings;

FIG. 21 represents an insertion tool with associated fastener and soft tissue anchor;

FIG. 22 represents an insertion sleeve associated with the tool shown in FIG. 21;

FIGS. 23-31 represent the repair of a rotator cuff using a tool shown in FIG. 21;

FIGS. 32-38 represent alternate methods for tying a suture anchor to the fastener;

FIG. 39 represents the suture anchor coupled to a two-piece fastener;

FIGS. 40-44 represent an alternate system and method of coupling soft tissue to the bone;

FIG. 45 is a side view of a bone cutting device constructed in accordance with the teachings of the present disclosure;

FIG. 46 is a cross-sectional view of the bone cutting device of FIG. 45 in an initial operative position in association with a bone of a body;

FIG. 47 is a cross-sectional view of the bone cutting device of FIG. 45 in a final operative position in association with the bone of the body;

FIG. 48 is a cross-sectional view of a bone socket established by the bone cutting device of FIG. 45 having a soft suture anchor inserted therewith;

FIG. 49 is a side view of an alternate bone cutting device constructed in accordance with the teachings of the present disclosure;

FIG. 50 is a cross-sectional view of the bone cutting device of FIG. 49 in an initial operative position in association with a bone of a body;

FIG. 51 is a cross-sectional view of the bone cutting device of FIG. 49 in an intermediate operative position in association with the bone of the body;

FIG. 52A is a cross-sectional view of the bone cutting device of FIG. 49 in a final operative position in association with the bone of the body and having a rigid body portion;

FIG. 52B is a cross-sectional view similar to that of FIG. 52A having a flexible body portion;

4

FIG. 53 is a cross-sectional view of a bone socket established by the bone cutting device of FIG. 49;

FIG. 54 is a side view of another alternate bone cutting device constructed in accordance with the teachings of the present disclosure;

FIG. 55 is a cross-sectional view of the bone cutting device of FIG. 54 in an initial operative position in association with a bone of a body;

FIG. 56 is a cross-sectional view of the bone cutting device of FIG. 54 incorporating a sleeve in a first intermediate operative position in association with the bone of the body;

FIG. 57 is a cross-sectional view of the bone cutting device of FIG. 54 incorporating the sleeve in a second intermediate operative position in association with the bone of the body;

FIG. 58 is a cross-sectional view of the bone cutting device of FIG. 54 in a final operative position in association with the bone of the body;

FIG. 59 is a cross-sectional view of a bone socket established by the bone cutting device of FIG. 54 and the sleeve of FIG. 56; and

FIG. 60 is a cross-sectional view of an alternate sleeve for use with the bone cutting device of FIG. 54.

Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features.

FIG. 2A represents a suture construction 20 according to the present teachings. Shown is a suture 22 having a first end 24 and a second end 26. The suture 22 is formed of a braided body 28 that defines a longitudinally formed hollow passage 30 therein. First and second apertures 32 and 34 are defined in the braided body 28 at first and second locations of the longitudinally formed passage 30.

Briefly referring to FIG. 3, a first end 24 of the suture 22 is passed through the first aperture 32 and through longitudinal passage 30 formed by a passage portion and out the second aperture 34. The second end 26 is passed through the second aperture 34, through the passage 30 and out the first aperture 32. This forms two loops 46 and 46'. As seen in FIG. 2B, the relationship of the first and second apertures 32 and 34 with respect to the first and second ends 24 and 26 can be modified so as to allow a bow-tie suture construction 36. As described below, the longitudinal and parallel placement of first and second suture portions 38 and 40 of the suture 22 within the longitudinal passage 30 resists the reverse relative movement of the first and second portions 38 and 40 of the suture once it is tightened.

The first and second apertures are formed during the braiding process as loose portions between pairs of fibers defining the suture. As further described below, the first and second ends 24 and 26 can be passed through the longitudinal passage 30 multiple times. It is envisioned that either a single or multiple apertures can be formed at the ends of the longitudinally formed passage.

As best seen in FIGS. 4A and 4B, a portion of the braided body 28 of the suture defining the longitudinal passage 30 can be braided so as to have a diameter larger than the diameter of the first and second ends 24 and 26. Additionally shown are first through fourth apertures 32, 34, 42, and 44. These apertures can be formed in the braiding process or can be formed during the construction process. In this regard, the apertures

32, 34, 42, and 44 are defined between adjacent fibers in the braided body 28. As shown in FIG. 4B, and described below, it is envisioned the sutures can be passed through other biomedically compatible structures.

FIGS. 5-7 represent alternate constructions wherein a plurality of loops 46a-d are formed by passing the first and second ends 24 and 26 through the longitudinal passage 30 multiple times. The first and second ends 24 and 26 can be passed through multiple or single apertures defined at the ends of the longitudinal passage 30. The tensioning of the ends 24 and 26 cause relative translation of the sides of the suture with respect to each other.

Upon applying tension to the first and second ends 24 and 26 of the suture 22, the size of the loops 46a-d is reduced to a desired size or load. At this point, additional tension causes the body of the suture defining the longitudinal passage 30 to constrict about the parallel portions of the suture within the longitudinal passage 30. This constriction reduces the diameter of the longitudinal passage 30, thus forming a mechanical interface between the exterior surfaces of the first and second parallel portions as well as the interior surface of the longitudinal passage 30.

As seen in FIGS. 8-11, the suture construction can be coupled to various biocompatible hardware. In this regard, the suture construction 20 can be coupled to an aperture 52 of the bone engaging fastener 54. Additionally, it is envisioned that soft tissue or bone engaging members 56 can be fastened to one or two loops 46. After fixing the bone engaging fastener 54, the members 56 can be used to repair, for instance, a meniscal tear. The first and second ends 24, 26 are then pulled, setting the tension on the loops 46, thus pulling the meniscus into place. Additionally, upon application of tension, the longitudinal passage 30 is constricted, thus preventing the relaxation of the tension caused by relative movement of the first and second parallel portions 38, 40, within the longitudinal passage 30.

As seen in FIGS. 9-11B, the loops 46 can be used to fasten the suture construction 20 to multiple types of prosthetic devices. As described further below, the suture 22 can further be used to repair and couple soft tissues in an anatomically desired position. Further, retraction of the first and second ends allows a physician to adjust the tension on the loops between the prosthetic devices.

FIG. 11B represents the coupling of the suture construction according to FIG. 2B with a bone fastening member. Coupled to a pair of loops 46 and 46' are tissue fastening members 56. The application of tension to either the first or second end 24 or 26 will tighten the loops 46 or 46' separately.

FIGS. 12A-12E represent potential uses of the suture constructions 20 in FIGS. 2A-7 in an ACL repair. As can be seen in FIG. 12A, the longitudinal passage portion 30 of suture construction 20 can be first coupled to a fixation member or fastener 60. The fixation member 60 can have a first profile which allows insertion of the fixation member 60 through the tunnel and a second profile which allows engagement with a positive locking surface upon rotation. The longitudinal passage portion 30 of the suture construction 20, fixation member 60, loops 46 and ends 24, 26 can then be passed through a femoral and tibial tunnel 62. The fixation member 60 is positioned or coupled to the femur. At this point, a natural or artificial ACL 64 can be passed through a loop or loops 46 formed in the suture construction 20. Tensioning of the first and second ends 24 and 26 applies tension to the loops 46, thus pulling the ACL 64 into the tunnel. In this regard, the first and second ends are pulled through the femoral and tibial tunnel, thus constricting the loops 46 about the ACL 64 (see FIG. 12B).

As shown, the suture construction 20 allows for the application of force along an axis 61 defining the femoral tunnel. Specifically, the orientation of the suture construction 20 and, more specifically, the orientation of the longitudinal passage portion 30, the loops 46, and ends 24, 26 allow for tension to be applied to the construction 20 without applying non-seating forces to the fixation member 60. As an example, should the loops 24, 26 be positioned at the fixation member 60, application of forces to the ends 24, 26 may reduce the seating force applied by the fixation member 60 onto the bone.

As best seen in FIG. 12C, the body portion 28 and parallel portions 38, 40 of the suture construction 20 remain disposed within to the fixation member 60. Further tension of the first ends draws the ACL 64 up through the tibial component into the femoral component. In this way, suture ends can be used to apply appropriate tension onto the ACL 64 component. The ACL 64 would be fixed to the tibial component using a plug or screw as is known.

After feeding the ACL 64 through the loops 46, tensioning of the ends allows engagement of the ACL with bearing surfaces defined on the loops. The tensioning pulls the ACL 64 through a femoral and tibial tunnel. The ACL 64 could be further coupled to the femur using a transverse pin or plug. As shown in FIG. 12E, once the ACL is fastened to the tibia, further tensioning can be applied to the first and second ends 24, 26 placing a desired predetermined load on the ACL. This tension can be measured using a force gauge. This load is maintained by the suture configuration. It is equally envisioned that the fixation member 60 can be placed on the tibial component 66 and the ACL pulled into the tunnel through the femur. Further, it is envisioned that bone cement or biological materials may be inserted into the tunnel 62.

FIGS. 13A-13D represent a close-up of a portion of the suture 20. As can be seen, the portion of the suture defining the longitudinal passage 30 has a diameter d1 which is larger than the diameter d2 of the ends 24 and 26. The first aperture 32 is formed between a pair of fiber members. As can be seen, the apertures 32, 34 can be formed between two adjacent fiber pairs 68, 70. Further, various shapes can be braided onto a surface of the longitudinal passage 30.

The sutures are typically braided of from 8 to 16 fibers. These fibers are made of nylon or other biocompatible material. It is envisioned that the suture 22 can be formed of multiple type of biocompatible fibers having multiple coefficients of friction or size. Further, the braiding can be accomplished so that different portions of the exterior surface of the suture can have different coefficients of friction or mechanical properties. The placement of a carrier fiber having a particular surface property can be modified along the length of the suture so as to place it at varying locations within the braided constructions.

FIGS. 14A and 14B represent the coupling of suture construction 22 of FIG. 2A and FIG. 4 to a bone. The longitudinal passage 30 is coupled to a fixation member 60 which can be disposed within an aperture formed in the bone. The fixation member 60 can be, for example, a staple or a bone engaging screw. After coupling the suture construction 22 to the bone, loops 46 and 47 and ends 24 and 26 are readily accessible by the physician. The application of tension to the ends 24 and/or 26 causes the loops 46 and 47 to constrict. The loops 46 and 47 can be used to couple two or more portions of the anatomy. In this regard, the loops can be used to couple bone to bone or soft tissue to bone.

FIGS. 15A-15G represent the coupling of soft tissue 80 to bone. As shown in FIGS. 15A and 15B, the suture construction 22 is disposed about a portion of the soft tissue 80. Alternatively, an aperture or hole 84 can be formed in the soft

7

tissue 80. A portion of the suture construction 22, for example, a loop 46 or loops 46, 47 or ends 24 and 26 can be threaded or pulled through the aperture 84. As seen in FIG. 15B, a single loop 46 of suture can be coupled to the fastener 60. This single loop 46 can be disposed over or around the soft tissue 80.

As shown in FIG. 15C, one loop 46 can have a fastening element 70 coupled thereto. This fastener element 70 can take the form of a loop of suture having a knot 72. This fastening element 70 along with the loop 46 and one or more strands 24 can be passed through the aperture 84 formed in the soft tissue 80.

FIG. 15D shows the second loop 47 can be passed around the soft tissue and coupled to the fastening element 70. The first and second loops 46 and 47 are coupled together about the soft tissue 80, and optionally can be positioned about the knot 72.

As shown in FIG. 15E, the first loop 46 and first end 24 can be passed through an aperture 84 of the soft tissue 80. Coupled to the first loop 46 is a fastener 70 in the form of a suture having a knot 72. The second loop 47 can be passed through the suture 70 and the knot 72 so as to form a pair of locking loops 73 (see FIG. 15F). FIG. 15G shows that tension can be applied to the first and second ends 24 and 26 of the suture 22 to constrict the suture 22 about the soft tissue 80. In this regard, the first and second loops 46 and 47 are tightened to constrict about and fix the soft tissue 80 to the bone.

As seen in FIG. 16A, the construction of FIGS. 14A and 14B can be modified so as to place a pair of collapsible fabric tubes 74 and 76 about a portion of the suture 22. In this regard, collapsible tubes 74 and 76 can be coupled to the first and second suture loops 46 and 47. It is also envisioned several collapsible tubes can be coupled to a single loop 46 or the suture ends 26, 27.

The collapsible tubes 74 and 76 can be either threaded onto (76) or disposed about a loop 75 formed in the suture loop 46. As seen in FIG. 16B, the first collapsible tube 76 can be fed through the loop 75. When tension is applied to the second end 26 of the suture 22, the first loop 46 constricts about the second loop causing the collapse of the first collapsible tube 74. As shown in FIG. 16D, tension can be applied to the first suture end 24 causing the second loop 47 to constrict causing the collapse of the second collapsible tube 76 and the subsequent locking of the soft tissue 80 to the bone.

FIGS. 17A-17E represent an alternate method for coupling soft tissue 80 to a bone using the construction of FIGS. 14A and 14B. As shown in FIG. 17A, the first loop 46 and first suture end 24 are passed through an aperture 84 formed in the soft tissue 80. The second loop 47 is passed through the first loop 46.

The second loop 47 is then doubled back over the first loop 46 causing a pair of intermediate loops 77. As shown in FIG. 17D, a locking member 70, soft or hard, can then be passed through the pair of intermediate loops 77 or a portion of the first loop 75 to lock the first and second loops 46 and 47 together. As shown in FIG. 17E, tension applied to the suture ends 26, 27 tightens the loops 46 and 47 about the locking member 70. The soft tissue 80 is also fixed to the bone.

FIGS. 18A-18C represent alternate suture constructions 22 which are used to couple soft tissue 80 and 81 to bone. Disposed about the first and second loops 46 and 47 are collapsible tubes 74 and 76. The tubes 74 and 76 which can be, for example, fabric or polymer, can either be directly disposed about the suture 22 of the first and second loops 46 and 47, or can be coupled to the suture loops 46 and 47 using a separate loop member 81.

8

As shown in FIG. 18C, the suture construction 22 shown in FIG. 18A or 18B, the collapsible tubes 74 and 76 are passed through the apertures 84 formed in the soft tissue 80. The application of tension to the ends 26 and 27 causes the soft tissue 80 to be drawn against the bone and cause compressive forces to be applied to the collapsible tubes 74 and 76. By tightening the suture which passes through the passage 30, the soft tissue 80 is coupled to the bone without the use of knots.

As can be seen in FIGS. 19A-19C, several fixation members 60 and 60' can be coupled to the suture construction 22 to fasten soft tissue 80 to bone. As seen in FIG. 19A, the collapsible tube 74 can be coupled to a first loop 46 while the second loop 47 can be used to couple the first suture 22 to the second fastener 60'. In this regard, they are coupled using a collapsible tube 76 of the second suture 22', thus allowing downward force along the entire length between the fasteners, thus providing bridge fixation as well as point fixation.

As seen in FIG. 19B, tension of the ends 24 and 26 of the first suture 22 draws the second loop 47 into the fixation member 60'. The second loop 47 of the first suture 22 is then coupled to the collapsed tube 76. This couples the first and second fasteners together and applies the downward force.

As seen in FIG. 19C, the second loop 47 of the first suture 22 can be passed through a second aperture 86 in the soft tissue 80. A second loop 47 is then coupled to the collapsible tube 76 associated with the second suture 22'. The collapsed tube 76 of the second suture 22' functions to fix the suture 22' to the fixation member 60'. It is envisioned the collapsed tube 76 can be found within a bore defined in the bone or the fastener 60.

FIGS. 20A and 20B represent the use of a suture construction 22 to repair a meniscus. Fasteners 82 are coupled to first and second loops 46 and 47.

After the fixation member 60 is coupled to bone or soft tissue, the first loop 46 is passed through a first aperture 84 in a first portion of the meniscus. The first loop and collapsible tube 74 is then passed through a second aperture 86 and a second portion of the meniscus. The second loop 47 and second collapsible tube 76 are similarly passed through the meniscus. Tension is applied to the first and second ends 24 and 26 of the suture 22 to pull the meniscus together. As seen in FIG. 20B, a first and second collapsible tube 74 and 76 are constricted so as to couple the suture to the meniscus.

FIG. 21 represents a tool 100 with associated fastener 102 and soft tissue anchor 104. The tool 100 has a handle portion 106 which releasably engages the fastener 102. Associated with the handle portion 106 is a hollow longitudinal suture 103 which accepts a soft tissue anchor 104. Disposed at a distal end 110 of the hollow longitudinal portion 108 is a slot having a portion of the soft tissue anchor 104 disposed there-through. The distal end 110 is further configured to support the fastener 102 for insertion into a bore defined within bone 112.

FIG. 22 represents an insertion guide 115 having a handle portion 114 and a curved longitudinal guide tube 116. The longitudinal guide tube 116 and handle portion 114 slidably accept the fastener 102 and soft tissue anchor 104. The curved longitudinal tube 116 and handle portion 112 define a slot 118 which also slidably accepts the suture 103 of soft tissue anchor 104.

FIGS. 23-38 generally depict the repair of labral tissue of a glenoid. While the repair shown generally relates to a specific anatomical injury, it is envisioned the teachings herein can be applied to other anatomical regions which require the coupling of soft tissue to bone. For example, a meniscal repair in a knee may be performed using similar techniques. As shown in FIG. 23, access to the region of the injury is made through

a tube **120**. At this point, a collapsible tube **122** having an extended portion **124** is threaded through tube **120** into close proximity of the soft tissue **126** to be coupled to bone. A suture grabber **128** such as a speed pass by Biomet Sports Medicine is used to pierce the soft tissue **126** and to grab the extended portion **124** of the collapsible tube **122**. This extended portion **124** is then pulled through the soft tissue **126**.

As shown in FIG. **24**, the extended portion **124** of the collapsible tube **122** is fed back out the access tube **120** and clamped with clamp **129** so as to prevent inadvertent translation with respect to the tube. As shown in FIG. **25**, the insertion sleeve **115** is placed through the access tube **120**. The collapsible tube **122** is placed through the slot **118** defined in the handle portion **114** and longitudinal guide tube **116**.

FIG. **26** shows a drill **130** having a flexible drive shaft **132** and a bone cutting drill bit **134**. The drill bit **134** is placed through the guide tube **116** to form a bore **136** in bone at a location adjacent to a soft tissue repair. It is envisioned the bore **136** can be placed under or adjacent the soft tissue repair.

After the bore **136** has been formed in the bone, the tool **100**, fastener **102**, and associated soft tissue anchor **104** are placed through the insertion guide **115**. As shown in FIG. **28**, the fastener is inserted into the bore **136**. It is envisioned the fastener **102** can be a two-part fastener having a first insertion portion **140** and a locking portion **142**. The locking portion **142** can have a plurality of expandable bone engaging members **144**.

As seen in FIG. **30**, the pair of sutures **146** can be pulled through the soft tissue **126**. The sutures **146** can be coupled together using a suture construction shown in FIG. **1A** or **1B**. In this regard, the suture **146** can be looped through an integrally formed collapsible member or tube **148** which can be used to fix the suture construction with respect to either the insert or locking portion **140**, **142** of the fastener.

As shown in FIG. **31**, when tension is applied to the suture **146** through the tool **100**, a collapsible portion **150** of the collapsible tube engages the soft tissue **126**. As seen in FIGS. **32-33B**, once the collapsible portion **150** of the collapsible tube is set, the tool **100** can be removed from the insertion guide **115**. At this point, the end of the longitudinal tube can be removed, or can be tied to the suture **146**.

FIGS. **34-36** represent an alternate method for coupling a suture construction **104** to the fastener **102**. Shown is a fastener **102** being passed through the loop of the suture. In this regard, the fastener **102** is passed through the loop of the suture prior to insertion of the fastener **102** within the bore **136** in the bone. After removal of the tool **100**, tension is applied to the ends of the suture to constrict the collapsible portion **150** of the collapsible tube. This tensioning pulls the soft tissue **146** into a position with respect to the fastener **102**.

As shown in FIGS. **37** and **38**, the fastener **102** can have an associated integral loop **120**. The integral loop **120** can be a suture or can be an integral polymer construction. The compressible tube **122** can be threaded through the integral loop **120**. Application of tension onto the suture causes the collapsible portion **150** of the collapsible tube to bear against the integral loop **120** and the soft tissue. It is envisioned the integral loop can be elastically deformable or can be fixed with respect to the fastener.

FIG. **39** represents a suture construction coupled to a two-piece fastener **102**. The suture construction **104** can be threaded through the aperture formed within the first or second portions of the fastener **102**. As shown, an integrally formed collapsible tube portion **148** can be disclosed within the aperture of the fastener. Upon application of tension onto

the suture, the tension will cause the collapse of this second collapsible tube portion **148**, thus locking the suture to the fastener body **102**.

FIGS. **40-44** represent an alternative system and method of coupling soft tissue to bone. By way of non-limiting example, a fastener **102** can be coupled to the bone as described above and shown in FIGS. **23-30**. Subsequent to this, the collapsible portion **150** of the tube **104** can be passed through the soft tissue **126**.

As best seen in FIGS. **40-42**, a drive tool **160** is used to form a soft tissue engagement site **162** in a bone structure. The tool **160** has a drive (not shown) which rotates a bone cutting bit **164**. The bone cutting bit **164** has a first portion **166** configured to drill a hole **167** through cortical bone and a threaded second portion **168**. The threaded second portion **168** is configured to cut threads in the cortical **169** and cancellous bone **171** structures. This is accomplished by advancing the cutting bit **164** into the bone at a predetermined rate while rotating the bit at a predetermined speed. As shown in FIG. **41**, after the second portion **168** has entered the cancellous bone **171**, the bit is rotated while keeping the rotating tool **160** in a substantially stationary position. The thread cutting threads of the second portion **168** then displace cancellous bone **171**, forming the cavity **162**. The bit is removed by rotating the thread cutting threads through the threads formed in the cortical bone **169**.

As shown in FIG. **43**, the collapsible tube **104** of suture anchor is passed through passage **167** and into the cavity **162**. In this regard, an insertion tool **173** can be used to insert the collapsible tube **104** into the cavity **162**. As shown in FIG. **44**, tension is applied to the end **172** of the suture anchor, thus causing the collapsible portion **104** of the anchor.

Referring now to FIGS. **45-47** of the drawings, an alternate bone cutting tool is generally indicated by reference number **200**. Bone cutting tool **200** can be any tool operable for forming an open- or closed-end bore having a shoulder in a bone **212** for receipt of a tissue-anchoring device (e.g., a tap as shown in FIGS. **45-47** or a drill as shown in FIGS. **49-60**). An exemplary anchoring device is a soft or flexible suture anchor **214**, such as the suture-anchoring device described in co-pending U.S. patent application Ser. Nos. 12/915,962 and 11/935,681, both incorporated herein by reference. Soft suture anchor **214** is operable for securing a tissue **216** (e.g., xenograft, allograft, or bone) to bone **212** (see FIG. **48**). Soft suture anchor **214** is illustrated to include a bone fixation element **218** and a tissue fixation element **220** interconnected through a suture **222**, as will be described below. Those skilled in the art will understand that soft suture anchor **214** may be formed from a non-resorbable material or a resorbable material of the types that are well known in the art so as to permit bone fixation element **218**, tissue fixation element **220**, and suture **222** to bioabsorb over a selected time span, such as within the time span of the healing process.

With particular reference to FIG. **45**, bone cutting tool **200** is shown to include an elongated body or shaft portion **224** having a first diameter **226**, at least one distally positioned helical cutting tooth or flute **228** defining a second diameter **230**, and a distal tapered end **232**. Body portion **224** includes a proximal end **234** configured for receipt by a driving device **236** (e.g., a handle or a chuck of a power drill) and a distal end **238** forming helical cutting tooth **228** and terminating at tapered end **232**. Helical cutting tooth **228** can be formed by machining the distal end **238** or otherwise connecting the tooth **228** to the distal end **238**. Body portion **224** extends along a longitudinal axis **240** and is configured so as to provide first diameter **226** as a constant over its length. Alternately, body portion **224** may have a varied diameter so as to

11

form an integral shoulder portion (not shown) at the proximal end **234** for receiving an external driving means (e.g., driving device **236**). Driving device **236** has a larger size than that of first diameter **226**, thereby forming a stop **242** therebetween that can act as a stop or depth limiter.

Helical cutting tooth **228** is coupled to body portion **224** and may extend therefrom by a predetermined length **244**, width **246**, and pitch **248**. For example, helical cutting tooth **228** may extend by length **244** from a distal most tip **250** of tapered end **232** towards proximal end **234**. Width **246** may correspond to a distance between an outer surface **252** of body portion **224** and an apex **254** of tooth **228**. Accordingly, the second diameter **230** of bone cutting tool **200** may be larger than the first diameter **226** of body portion **224**. Notably, predetermined length **244**, width **246**, and pitch **248** can be varied to provide an appropriately dimensioned bone pocket **256** for receipt of soft suture anchor **214**, to accommodate varying bone constructs and densities. Additionally, body portion **224** may have a length **258** extending from distal most tip **250** to stop **242** for establishing the location of bone pocket **256** within the bone **212**. For example, length **244** may be 5.0 to 15.0 mm, width **246** may be 0.5 to 1.0 mm, pitch **248** may be 2.0 to 4.0 mm, and length **258** may be 10.0 to 20.0 mm.

Referring now to FIGS. **46-48**, the foregoing bone cutting tool **200** may be used to form a blind bore, concavity, or hole having a substantially uninterrupted 360° internal shoulder **272** within bone **212**. In particular, distal most tip **250** is brought into contact with an outer surface **260** of bone **212**. Bone cutting tool **200** is rotated around longitudinal axis **240** by manipulation of driving device **236**. Bone cutting tool **200** gradually moves or is driven into and through outer surface **260** of bone **212** by the cutting action of helical cutting tooth **228**. Helical cutting tooth **228** pulls bone cutting tool **200** into bone **212** in a corkscrew motion designed to draw the bone cutting tool **200** inwardly. It should be understood that bone cutting tool **200** is designed to penetrate cortical bone and establish bone pocket **256** within either cancellous or cortical bone. It should be noted, however, that bone cutting tool **200** may be sized to provide bone pocket **256** completely within cortical bone. In either case, bone cutting tool **200** produces a hole, concavity, or blind bore **262** within bone **212** having an inner diameter **264** that corresponds to first diameter **226**. Bone cutting tool **200** proceeds inwardly of bone **212** until stop **242** meets outer surface **260**.

Helical cutting tooth **228** establishes a single helical groove **266** in cylindrical bore **262** during inward rotation, as can be seen in FIG. **2**. Single helical groove **266** extends from outer surface **260** to the beginning of distal tapered end **232** when the bone cutting tool **200** is at the predetermined desired depth into the bone **212**. Without removing bone cutting tool **200** from bore **262**, bone cutting tool **200** is then repeatedly or continuously rotated around longitudinal axis **240** by manipulation of driving device **236**, so as to mill out bone pocket **256**. The continuous rotation bores a portion of bone **212** to a second, inner diameter **268** about equivalent to the distance from opposing-facing apices **254** of tooth **228**, as can be seen in FIG. **47**. In other words, the bone cutting tool **200** is continuously rotated at the predetermined depth to establish the enlarged bone pocket **256** at the distal end of the bore **262**. The inner diameter **268** of the bone pocket **256** is diametrically greater than the size of the inner diameter **264** of the bore **262**. Bone cutting tool **200** is then slowly backed out of bone **212** leaving bore **262** terminating at bone pocket **256**. In order to back bone cutting tool **200** out of bone **212**, helical cutting tooth **228** may be brought back into engagement with the helical groove **266** in the bore **262**. This may be achieved by putting slight back pressure on driving device **236**, so as to

12

allow helical cutting tooth **228** to catch on the single helical groove **266** in the cylindrical bore **262**. The bone cutting tool **200** is then rotated around the longitudinal axis **240**, but in reverse. Alternatively, a second helix form may be established during outward rotation of bone cutting tool **200** (not shown).

As can be seen in FIG. **48**, bone pocket **256** includes a tapered cone **270** corresponding in shape and size to distal most tip **250**, inner diameter **268** corresponding to the second diameter **230**, and a substantially uninterrupted 360° shoulder **272** defined between the bore **262** and the bone pocket **256**. Tapered cone **270** may terminate at a location within the bone **212** corresponding in length to the distance between stop **242** and distal most tip **250**, or in other words length **258** (e.g., 15.0 mm). Shoulder **272** may be located within the bone **212** at a distance from outer surface **260** at a dimension equal to the difference between length **258** and length **244** (e.g., 5.0 mm).

Bone pocket **256** is sized to receive a deformable fixation device, such as soft suture anchor **214**. It should be understood that while one exemplary soft suture anchor **214** is described herein, other anchoring devices are contemplated. For example, soft anchors having a single suture extending therethrough or rigid anchors, may be used. Soft suture anchor **214** can be preformed to include a looped configuration having at least one looped suture **222** and a pair of flexible anchors or bone fixation element **218** and tissue fixation element **220**, as described in co-pending U.S. patent application Ser. No. 12/915,962, incorporated herein by reference. In one example as shown herein, looped suture **222** may traverse a path from one end of bone fixation element **218** to the other end thereof. Soft suture anchor **214** can be formed by passing a first suture end **274** through a first aperture **276** in bone fixation element **218** and out a second aperture **278** in bone fixation element **218**. A second end **280** is then passed in through second aperture **278** in bone fixation element **218** and out first aperture **276** in bone fixation element **218**. Passing ends **274**, **280** through apertures **276**, **278** can form looped suture **222**. Similarly, ends **274**, **280** are passed through apertures **282**, **284** of tissue fixation element **220**.

The soft suture anchor **214** has a first configuration during installation and a second configuration upon applying tension to first and second ends **274**, **280**. In particular, the configuration of the looped suture **222** can be placed in a desired tension to engage shoulder **272**. Tension in looped suture **222** can cause constriction throughout soft suture anchor **214**. This constriction can cause soft suture anchor **214** to “automatically” lock in a compressed configuration. Further tension on ends **274**, **280** causes tissue **216** to be brought into engagement with outer surface **260** of bone **212**. This can fix selected tissue **216** (e.g., a ligament) to bone **212** in which the bone pocket **256** is formed.

With reference now to FIGS. **49-53**, another alternative bone cutting tool **300** is shown. Bone cutting tool **300** is also operable for preparing a bone **312** for receipt of a tissue anchoring device, such as soft suture anchor **214**, as previously described. Soft suture anchor **214** is not described in conjunction with bone cutting tool **300**; however, its insertion within a bone pocket **356** is similar to that described with reference to bone cutting tool **200** and bone pocket **256** as shown in FIG. **48**.

With particular reference to FIG. **49**, bone cutting tool **300** is shown to include a shaft or body portion **324**, a tubular sleeve **386**, and a tapered drill end **332**. Body portion **324** includes a proximal end **334** configured for receipt of a driving device **336** (e.g., a handle, a chuck of a power drill) and a distal end **338** supporting tapered drill end **332**. While body portion **324** is described as receiving driving device **336**, it

13

should be understood that distal end 338 may also terminate in an expanded shoulder (not shown) capable of insertion within a chuck (not shown) of the driving device 336. Furthermore, driving device 336 may be an integral piece used as a depth stop and also as a pivot point when maneuvering the drill (see FIG. 52A).

Tapered drill end 332 of bone cutting tool 300 may terminate at a distal most tip 350. Tapered drill end 332 can include cutting teeth or flutes 328 for axial and/or transverse cutting. Tapered drill end 332 may be self-tapping, so as to omit the need for a second, preparatory tool. Body portion 324 is situated along a longitudinal axis 340 and is configured to have a constant shaft diameter 326 over its length. Body portion 324 may be formed from a rigid material (e.g., stainless steel) or may be a more elastic material (e.g., nitinol).

Sleeve 386 may have a predetermined length 344, outer diameter 346, and concentric inner diameter 348 and may be slidably coupled to body portion 324. Length 344 and outer diameter 346 of sleeve 386 may correspond to a selected depth and width of cut in bone 312, as outer diameter 346 of sleeve 386 is approximately equal to an outer diameter 330 of tapered drill end 332. Notably, predetermined length 344 and outer diameter 346 can be varied to provide an appropriately dimensioned bone pocket 356 for receipt of soft suture anchor 214, to accommodate varying bone constructs and densities. Inner diameter 348 may be slightly larger than shaft diameter 326, so as to allow sleeve 386 to glide over body portion 324 during use. Sleeve 386 may be a rigid material (e.g., stainless steel), so as to provide stiffness to body portion 324 during insertion into bone 312. Sleeve 386 may also work as a centralized cutting guide for bone cutting tool 300 during insertion into bone 312, as will be described in detail below.

Referring now to FIGS. 50-53, the foregoing bone cutting tool 300 may be used to form an undercut or shoulder 372 in bone 312. In particular, distal most tip 350 is brought into contact with an outer surface 360 of bone 312. Bone cutting tool 300 is rotated around longitudinal axis 340 by manipulation of driving device 336. Gradually, bone cutting tool 300 moves into and through outer surface 360 of bone 312 by the cutting action of tapered drill end 332. Bone cutting tool 300 produces a bore 362 within bone 312 having an inner diameter 364 that corresponds to the outer diameter 330 of tapered drill end 332 and outer diameter 346 of sleeve 386. Bone cutting tool 300 advances inwardly of bone 312 until a desired cutting depth is reached.

Sleeve 386 is then retracted from bore 362 within bone 312. Bone cutting tool 300 can then be further rotated by manipulation of driving device 336. As body portion 324 and tapered drill end 332 are no longer supported by sleeve 386, they are allowed to freely move within bore 362. The movement can be either randomized or can be cyclical as performed by a user, but is typically defined as a pivot of the body portion 324 near the entrance to the bore 362. The side or transverse cutting flutes 328 allow cutting of bone 312 transverse to the axis 340.

It should be understood that when body portion 324 can be formed from an elastic material, the range of tapered drill end 332 may be greater than when body portion 324 is formed from a rigid material. For example, FIG. 52A shows body portion 324 formed from a rigid material, while FIG. 52B shows body portion 324 formed from an elastic material. As can be seen, a diametrical range 388 of tapered drill end 332 in FIG. 52A is smaller than that of a diametrical range 390 of tapered drill end 332 in FIG. 52B. While body portion 324 is described and illustrated as a straight shaft, it should be understood that body portion 324 may also be formed to include a multi-piece pivoting arrangement (e.g., a pivot driver). In this

14

way, body portion 324 may include an elbow (not shown) at a midpoint thereof. The elbow can allow the body portion 324 to flex in a mode similar to that shown in FIG. 52B. Therefore, size of bone pocket 356 is directly related to material and/or configuration of body portion 324. Bone cutting tool 300 may then be oriented with bore 362 and then backed out of bone 312. In this way, all cutting operations are performed without removing bone cutting tool 300 from bore 362.

As can be seen in FIG. 53, bore 362 terminates at bone pocket 356. Bone pocket 356 includes a widened socket 370 including an arc-shaped distal end 392 and a convex shoulder 372 forming a circumferential tooth 394. The arc-shaped distal end 392 corresponds to the path of cutting of the distal most tip 350. The arc-shaped distal end 392 may be adjacent to an angled side 396 corresponding to the profile of the tapered drill end 332. The angled side 396 may extend around a periphery of the arc-shaped distal end 392 and may terminate at the circumferential tooth 394 of the convex shoulder 372. The convex shoulder 372 may extend 360° around the periphery of the bore 362 between the widened socket 370 and the bore 362. While the bone pocket 356 is shown with a symmetrical arrangement, it should be understood that the bone pocket 356 may also have an asymmetrical arrangement dictated by the cyclical movement of the bone cutting tool 300. In either case, however, bone pocket 356 is sized to receive soft suture anchor 214, as previously described. It should be understood that the selection of shaft material may be directly related to the size of the suture anchor to be inserted within the bone pocket 356. For example, the larger size of the bone pocket 356 obtained with a flexible material may be necessary for larger suture anchors.

With reference now to FIGS. 54-60, an alternative bone cutting tool 400 is shown. Bone cutting tool 400 is also operable for preparing a bone 412 for receipt of a tissue anchoring device, such as soft suture anchor 214, as previously described. Soft suture anchor 214 is not described in conjunction with bone cutting tool 400; however, its insertion within a bone pocket 456 is similar to that described with reference to bone cutting tool 200 and bone pocket 256 as shown in FIG. 48.

With particular reference to FIG. 54, bone cutting tool 400 is shown to include a body portion 424, a sleeve 486, and a tapered drill end 432. Body portion 424 includes a proximal end 434 configured for receipt of a driving device 436 (e.g., a handle, a chuck of a power drill) and a distal end 438 supporting tapered drill end 432. Tapered drill end 432 of bone cutting tool 400 may terminate at a distal most tip 450. Body portion 424 extends along a longitudinal axis 440 and is configured to have a constant shaft diameter 426 over its length. Body portion 424 may be formed from a rigid material (e.g., stainless steel).

Sleeve 486 may have a predetermined length 444 and outer diameter 446. Sleeve 486 may also have a non-concentric or offset inner aperture 448, a flange 498, and a chamfered end 499. Length 444 of sleeve 486 may correspond to a selected depth of cut in bone 412 with flange 498 limiting movement of sleeve 486, as will be described in more detail below. Outer diameter 446 may correspond to an outer diameter 430 of tapered drill end 432. Furthermore, inner aperture 448 may be slightly larger than shaft diameter 426 so as to allow sleeve 486 to glide over body portion 424 during use. As should be understood, diameters 430, 446 and location of offset inner aperture 448 can be varied to provide an appropriately dimensioned bone pocket 456 for receipt of soft suture anchor 214, to accommodate varying bone constructs and densities.

Referring now to FIGS. 55-59, the foregoing bone cutting tool 400 may be used to form an undercut in bone 412 with

15

sleeve **486** working as a guide for cutting bone pocket **456** after insertion to appropriate depth into bone **412**. In particular, distal most tip **450** is brought into contact with an outer surface **460** of bone **412**, while sleeve **486** is located at a position away from the tapered drill end **432**. Bone cutting tool **400** is rotated around longitudinal axis **440** by manipulation of driving device **436**. Gradually, bone cutting tool **400** moves into and through outer surface **460** of bone **412** by the cutting action of tapered drill end **432**. Bone cutting tool **400** may establish a bore **462** within bone **412** having an inner diameter **464** that corresponds to the outer diameter **430** of tapered drill end **432**. Bone cutting tool **400** advances inwardly of bone **412** until an appropriate cutting depth is reached.

Chamfered end **499** of sleeve **486** is then inserted into bore **462**. Continuous rotation of bone cutting tool **400** by manipulation of driving device **436**, while simultaneously applying axial and rotational force to sleeve **486**, causes eccentric rotation of tapered drill end **432** allowing the sleeve **486** to be inserted into the bore **462**. Movement of sleeve **486** into bore **462** forces body portion **424** and tapered drill end **432** to cut into bore **462** in a spiraled offset manner. Sleeve **486** is prevented from moving further into bone **412** by flange **498**. As bone **412** is removed from bore **462**, a bone pocket **456** is formed having a 360° shoulder **472** therewith. Each rotation of tapered drill end **432** causes sleeve **486** to more freely move within bore **462**. Accordingly, tapered drill end **432** begins to move freely within bore **462**, but only to the extent permitted by the dimensional offset of inner aperture **448**.

As can be seen in FIG. **58**, bone cutting tool **400** is then centered and reversed out of bore **462** and bone **412**. Bone pocket **456** includes a widened socket **470** and 360° shoulder **472**, corresponding in shape and size to tapered drill end **432**. Bone pocket **456** is sized to receive soft suture anchor **214**, as previously described.

With reference now to FIG. **60**, an alternate sleeve **586** is shown for attachment to the bone cutting tool **400**. Sleeve **586** includes an offset inner aperture **548** and a flange **598**, which function as described above. Accordingly, alternative sleeve **586** is similar to the sleeve **486** of FIGS. **54-59**, but does not include chamfered end **499**. When sleeve **586** is in use, bone cutting tool **400** may be manually angled to allow for insertion of sleeve **586** into bore **462**.

The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. For example, any of the above mentioned surgical procedures is applicable to repair of other body portions. For example, the procedures can be equally applied to the repair of wrists, elbows, ankles, and meniscal repair. The suture loops can be passed through bores formed in soft or hard tissue. It is equally envisioned that the loops can be passed through or formed around an aperture or apertures formed in prosthetic devices e.g. humeral, femoral or tibial stems. Further, the suture material and collapsible tubes can be formed of resorbable material. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

What is claimed is:

1. A method for attaching a fixation device to a bone, the method comprising:

bringing a bone cutting tool that extends along a longitudinal axis into engagement with an outer surface of the bone;

rotating the bone cutting tool about the longitudinal axis while driving the bone cutting tool from the outer surface of the bone to a predetermined depth in the bone to form a bore;

16

continuously rotating the bone cutting tool at the predetermined depth while maintaining the bone cutting tool in a substantially stationary position to establish an enlarged bone pocket at a distal end of the bore, the bone pocket defining a shoulder extending around a circumference between the bone pocket and the bore;

removing the bone cutting tool from the bone pocket and the bore;

inserting the fixation device into the bone pocket through the bore; and

positioning the fixation device against the shoulder of the bone pocket.

2. The method of claim 1, wherein continuously rotating the bone cutting tool is performed without removing the bone cutting tool from the bore and after rotating the bone cutting tool into position at the predetermined depth.

3. The method of claim 1, wherein rotating the bone cutting tool about the longitudinal axis pulls the bone cutting tool into the bore.

4. The method of claim 3, further comprising:

creating a helical groove relative to the bore as the bone cutting tool is rotating about the longitudinal axis.

5. The method of claim 3, wherein rotating the bone cutting tool about the longitudinal axis is performed until a stop at a proximal end of the bone cutting tool engages the outer surface of the bone.

6. The method of claim 1, further comprising:

removing the bone at the distal end of the bore to form the bone pocket by the continuously rotating the bone cutting tool at the predetermined depth.

7. The method of claim 1, wherein rotating the bone cutting tool about the longitudinal axis includes forming a first aperture in the bone with a portion of the bone cutting tool having a first diameter.

8. A method for attaching a fixation device to a bone, the method comprising:

bringing a bone cutting tool having a helical flute into engagement with an outer surface of the bone;

rotating the bone cutting tool about a longitudinal axis to form a first bore having a helical flute groove extending from the outer surface of the bone to a depth within the bone;

continuously rotating the bone cutting tool at the depth to establish a second bore having a shoulder and a continuous sidewall, the shoulder extending around a circumference between the second bore and the first bore;

aligning the bone cutting tool with the first bore;

drawing the bone cutting tool out of the second and first bores;

inserting the fixation device into the second bore through the first bore; and

positioning the fixation device against the shoulder of the second bore.

9. The bone cutting tool of claim 8, wherein continuously rotating the bone cutting tool is performed while maintaining the bone cutting tool in a substantially stationary position without removing the bone cutting tool from the first bore.

10. The bone cutting tool of claim 8, wherein rotating the bone cutting tool about the longitudinal axis pulls the bone cutting tool into the bore.

11. The bone cutting tool of claim 10, wherein rotating the bone cutting tool about the longitudinal axis is performed until a stop at a proximal end of the bone cutting tool engages the outer surface of the bone.

17

12. The method of claim 8, further comprising:
transversely cutting the bone while maintaining the bone
cutting tool in a substantially stationary position to
establish the second bore.

13. The method of claim 8, wherein aligning the bone
cutting tool with the first bore further comprises reverse rotat- 5
ing the bone cutting tool to prevent further bone removal as
the bone cutting tool is drawn out of the second and first bores
along the helical flute groove formed in the first bore.

14. A method for attaching a fixation device to a bone, the 10
method comprising:

advancing a bone cutting tool through cortical bone about
a longitudinal axis of the tool to a predetermined depth in
cancellous bone to form a bore having a helical groove,
the bone cutting tool including 15

a body portion extending from a proximal end to a distal
end along the longitudinal axis,

a first member extending radially outwardly from the
distal end of the body portion, the first member having
a first diameter defined by at least one transverse 20
cutting flute, and

a second member extending radially outwardly from the
body portion proximal the first member and having a
second diameter greater than the first diameter; and 25
continuously rotating the bone cutting tool at a substan-
tially stationary position at the predetermined depth to
establish an enlarged bone pocket having a cylindrical
sidewall at a distal end of the bore, the bone pocket
defining a shoulder extending around a circumference
between the bone pocket and the bore.

18

15. The method of claim 14, further comprising:
removing the bone cutting tool from the bone pocket and
the bore;

inserting the fixation device into the bone pocket through
the bore; and

positioning the fixation device against the shoulder of the
bone pocket.

16. The method of claim 14, wherein the second member is
a stop extending radially outwardly from the body portion at
the proximal end, the stop engaging an outer surface of the
cortical bone for establishing the predetermined depth in the
cancellous bone.

17. The method of claim 14, wherein the second member is
a threaded portion sized for forming the enlarged bone
pocket.

18. The bone cutting tool of claim 14, wherein continu-
ously rotating the bone cutting tool is performed without
removing the bone cutting tool from the bore and after rotat-
ing the bone cutting tool into position at the predetermined
depth.

19. The bone cutting tool of claim 14, wherein rotating the
bone cutting tool about the longitudinal axis includes forming
a first aperture in the bone with the first member of the bone
cutting tool.

20. The bone cutting tool of claim 19, wherein continu-
ously rotating the bone cutting tool forms the bone pocket
having a pocket diameter substantially equal to the second
diameter of the second member.

* * * * *